Report no 96/EE 63 November, 1997

Areawide environmental quality management (AEQM) plan for the mining belt of Goa state

---

Final Draft Report submitted to

Directorate of Planning and Statistics, Government of Goa, Panaji

Goa

Energy Environment Interface

Tata Energy Research Institute

Project team

Dr M Ligia Noronha - Principal Investigator
Mr P V Sridharan
Dr Subrato Sinha
Ms Neeta Sharma
Dr S Sreekesh
Mr Arun Kansal
Dr S P Banerjee
Mr O N Kaul
Mr Sudheer M Khalwadekar
Mr P Sabri Nath
Ms Akhila Rajinder
Ms Alka Nagpal
Mr N Anand Kumar
Mr R K Joshi

Advisors
Dr A G Chachadi
Mr Abreu
Mr J M Chowdhry

Acknowledgment

This study was sponsored by the Directorate of Planning, Statistics and Evaluation, Government of Goa. The study was truly a multidisciplinary effort, and as such the team would like to thank the many that have helped it to ensure that the various aspects of relevance and importance were covered. In special, we would like to acknowledge the continuous support and encouragement of the Chief Minister of Goa, Shri Pratap Singh Rane who has taken a keen interest in this study

We would like to take this opportunity to specially thank:

Dr K S R V S Chalam, Director , Directorate of Planning and Statistics and other officers of the department.

The Director, Department of Industries and Mines and Shri S Mahambre of the Department of Mines.

Dr R N Ray, Chief Town Planner and other officers of the Town and Country Planning Department.

Conservator of Forests and Deputy Conservator of Forest, Government of Goa.

Department of Agriculture, Government of Goa.

Dr G N Nayak and Dr Peter R D'Souza of Goa University

Mr A N Bose, Controller General, IBM and his team of officers, Nagpur.

Mr Ashok Kumar, Regional Controller of Mines, IBM, Goa.

Dr Subhan Khan, Scientist, National Institute of Science, Technology, and Development Studies (NISTADS), Delhi.

Goa Mineral Ore Exporters Association.

All the mine companies who gave us access to their mines and information on various aspects.

All persons involved with the conducting of the socio-economic survey in the villages.

The village panchayats, the various individuals in key positions in the mining belt and finally to the villagers who gave us freely and generously their time.

Table of Contents

CHAPTER1 1

Introduction, objectives and methodology 1

Background 1

AEQM concept 1

State of Goa 4

The AEQM study area 7

Objectives and terms of reference of the study 7

Methodology/Approach 8

Organization of the study 9

Database and sources 9

CHAPTER 2 13

Present economic and social conditions 13

Economic scenario of the State 13

Role of mining in the state economy 13

Export earnings from iron ore 14

Royalty payment to the state government 15

Local economy 15

Economic activities in the study area 16

Mining 16

Ore beneficiation 22
Pelletization plant 23
Ore transportation by trucks 23
Ore transportation by barges 24

Socio-economic scenario 24
Basic indicators 25
Population and literacy 25
Worker distribution 26
Health and education facilities 27

Results of the socio-economic survey 27
Length of residency of households 27
Economic dependence of households on mining 28
Dependence on agriculture 29
Dependence on irrigation for agriculture 29
Literacy in the clusters 30
Status of women in the community 31
Gender literacy 31
Amenities available in the mining belt 31
Opinions of the households about mining activities in their area 35
Construction of the societal index 38

Summary 40

CHAPTER3 59

Present status of environmental quality **59**

Introduction 59

Unique features of iron ore mining in Goa 59

Climate 60

Topography and drainage 73

Environmental quality of the study area 73
Land 73
Impact on forest land 82
Impact on land and soil quality 83

Impact on agriculture land ... 87
Land rehabilitation ... 91
Status of reclamation of dumps ... 93
Status of land rehabilitation efforts ... 97
Air ... 98
Water ... 123
Surface water quality in the mining area ... 124
Opa water works ... 146
Ground water quality in wells surrounding the mines ... 155

Summary ... 163

CHAPTER4 ... **187**

The future of mining in Goa from a resource and a societal viewpoint ... 187

All India production and export of iron ore ... 187

All India iron ore production projection by Working Group ... 188

Iron ore production projection for Goa ... 188

Closure of mines in some leases ... 189

Production plan for the future ... 191

The peoples opinion on future of mining in Goa ... 194

Summary ... 200

CHAPTER5 ... **201**

Environmental impact assessment and management strategies for control ... 201

Impact on land environment due to mining operations ... 201

Land rehabilitation status and future plans ... 203

Impact on forests ... 205

Resettlement and rehabilitation of affected population ... 205

Impact on air quality 207

Impact on water resources 211

Management Strategies (MS) for control 212

MS-1: Planned improvements including additional control measures 212

MS-2: Fugitive dust reduction on roads and alternate roads for ore transport 238

MS-3: Measures to alleviate some of the societal problems affecting mining villages 244

MS-4 Planning for closure of mines 249

Environmental and social cost analysis 257

Management strategy evaluation 265

CHAPTER6 269

Improved environmental behaviour: The institutional dimensions 269

Introduction 269

Regulatory arrangements 269

The environmental law framework 270

Operationalizing the instruments of control 272

The mining plan 274

Enforcement of EPA Act and other environmental Acts and Rules 275

'Consent to establish' and 'Consent to operate' 275

The 'safety aspects' 276

'Greening and de-greening' of the mining belt 277

'Creeping expropriation' 277

Falling by the wayside 278

Institutional requirements 281

Monitoring network for ambient environmental quality 284

Investment for monitoring activities 290

Environmental auditing 292

CHAPTER 7 . . . . . **295**

Conclusions and recommendations **295**

Present conditions 295

Management strategies 296

Recommendations 298

List of Tables

Table 2.1. Sectoral share of Net State Domestic Product (NSDP) (in %) ... 13
Table 2.2. Contribution of the mining industry to NSDP (1970-71 to 1994-95) ... 14
Table 2.3. Quantity and value of iron ore exported from Goa, 1990-91 to 1996-97 ... 15
Table 2.4 Sectoral shares of total income of the mining belt (%) ... 15
Table 2 5 Area and population of clusters in relation to the mining talukas ... 18
Table 2.6. Cluster wise mining details ... 20
Table 2.7. Cluster and mine wise ore production from 1991 to 1995 ... 20
Table 2.8 Company wise average production and export (1993-94 and 1995-96) ... 22
Table 2.9 Villages/towns in the area ... 25
Table 2.10. Population and literacy ... 25
Table 2.11 Worker distribution by clusters ... 26
Table 2.12. Sector-wise distribution of workers by clusters, 1991 (%) ... 26
Table 2.13. Education and health facilities ... 27
Table 2 14. Length of residence - cluster wise (% households) ... 28
Table 2.15 Main reasons for migration (% households) ... 28
Table 2.16. Cluster wise dependence on mines (% households) ... 29
Table 2 17. Percentage of households undertaking farming ... 29
Table 2.18 Irrigation used by households cluster-wise (% households) ... 30
Table 2 19 Literacy levels distributed gender wise (%) ... 30
Table 2.20. Source of drinking water for clusters (% households) ... 32
Table 2.21. Distance traveled to a water source (% households) ... 33
Table 2 22. Extent of electrification in the clusters (% households) ... 33
Table 2 23 Cluster wise household availability of sanitation facilities (% households) ... 33
Table 2 24 Types of houses (% households) ... 34
Table 2 25 Types of fuel used in the clusters (% households) ... 34
Table 2.26. Distance traveled to collect fuel wood (% households) ... 35
Table 2.27. Opinion about amenities provided by the mine companies ... 35
Table 2.28. Opinion about whether the village has benefitted from mining ... 36
Table 2 29 Identified issues of concern (% households) ... 37
Table 2.30 Village-wise societal index parameters ... 41

Table 3.1. Cluster-wise land utilization pattern (in sq km) ... 74
Table 3.2 Changes in land use pattern over 1988-1997 (in hectares) ... 77
Table 3.3. Forest land area affected due to mining operations (hectares) ... 82
Table 3.4. Change in vegetative cover ... 83
Table 3.5. Reclamation (through updation) status of dumps (estimated)
(figures in hectare) ... 93

Table 3.6 Ambient air quality standards ($\mu g/m^3$) 99
Table 3.7. Seasonal variation of air quality for few villages/settlements in cluster (in $\mu g/m^3$) 99
Table 3.8. Workers exposure to mine dust 105
Table 3.9. Air quality status in road traffic corridor 106
Table 3.10. Dust concentration at the source 108
Table 3.11. Air quality for villages (in $\mu g/m3$) 109
Table 3.13 Air quality and population density 110
Table 3.14. Air quality status 111
Table 3.15 Classification of inland surface water, CPCB standard 123
Table 3.16. Water quality of some rivers and lakes 125
Table 3.17 Impacts on water bodies due to mining activities in villages 134
Table 3.18. Summary of impacts on water bodies due to mining activities 142
Table 3.19 Wastewater management practices of mines 143
Table 3.20. Findings of the inspection report of mines in Khandepar river catchment . 147
Table 3.21. Groundwater quality surrounding the mines 155
Table 3.21 Villages affected by mining activities 164
Table 4.1 All India production and export of iron ore (Mt) 187
Table 4.2. Projected production capacity of existing iron ore mines in India (Mt) . . . 188
Table 4.3 Estimated life of mines based on R/P ratio 189
Table 4.4 Future production plan in the study area (lakh tonnes) 192
Table 4.5. Peoples perception about mining activity - Cluster I (% household) 194
Table 4.6 Peoples perception about mining activities - Cluster II (% households) . . 196
Table 4.7 Peoples perception about mining activity - Cluster III (% household) 197
Table 4.9. Perceived causes for health problems in the future (% household) 199
Table 4.10 Peoples perception about beneficiaries of mining 200

Table 5.1 Clusterwise, villagewise ore production and land requirement for mining 1997-2012. 202
Table 5.2 Villagewise status of land reclaimed and reclamation plan (1997-2012). 204
Table 5.3. Villagewise SPM concentration levels and AQI in 2012 (under business as usual scenario) 208
Table 5.4 Control measures at dust generation source 213
Table 5.5 Village wise estimated AQI under BAU and MS-1 and control measures . 214
Table 5.6 Recommended trees for shelter bed 230
Table 5.7. Forecast of rail transportation of iron ore from Bellary-Hospet area (Mt) . . . 243
Table 5.8 Suggestions for economic activities (% households) 246
Table 5.9 New skills most wanted by women 247
Table 5.10. Details of water treatment schemes 259
Table 5.11. Cost estimation for units under scheme I. 259
Table 5.12. Cost estimation for the filtration unit under scheme II. 260

Table 5.13 Cost details for roads 260
Table 5.14 Cost analysis for different strategies 263
Table 5.15 Average costs (Rs per tonne) 265

Table 6.1 Relevant regulations - enforcement status in the mining area 279
Table 6.2. Agencies responsible for implementation of the AEQM plan 284
Table 6.3. Air quality monitoring stations 285
Table 6.4. Air quality monitoring schedule 286
Table 6.5 Mineral and salinity classification of water 287
Table 6.6 Surface and ground water monitoring stations 288
Table 6.7 Methods of determination of critical parameters of water, wastewater and monitoring 289
Table 6.8. Investment requirement for monitoring network 291
Table 6.9 List of equipments for laboratory facilities 292

List of Annexures

CHAPTER1 1

Introduction, objectives and methodology 1

Annexure 1.1 Cluster wise name of study villages 11

CHAPTER 2 13

Present economic and social conditions 13

Annexure 2 1 Area and population, of villages in the study area 43

Annexure 2.2 Iron ore resource base in Goa 45

Annexure 2.3 Mine-wise and village wise iron ore reserves (Million tonnes) 47

Annexure 2 4: List of leases granted, operating and applied for renewal in the four clusters 49

Annexure 2 5 Cluster-wise details of dry screening plants 54

Annexure 2 6 Cluster-wise details of wet beneficiation plants 55

Annexure 2 7 Cluster wise details of barge loading points 56

CHAPTER3 59

Present status of environmental quality 59

Annexure 3 1 Month wise rainfall recorded for North Goa (in mm) 171

Annexure 3 1b Month wise rainfall recorded in South Goa (in mm) 172

Annexure 3 2 Village wise land use pattern (based on satelliate imaginary - 1997 interpretation) (in hectares) 173

Annexure 3 3 Analysis of samples collected 177

Annexure 3 4 Physico-chemical properties of soil in Bicholim Taluka (MoEF Study) 178

Annexure 3 5 Analysis of soil samples collected from agricultural feilds and plantations (South Goa) 179

Annexure 3.6 Analysis of soils of agricultural fields and plantations (North Goa) 181

Annexure 3.7 Analyses of samples collected from Sonshi mine area 182

Annexure 3 8 Analysis of samples collected at Pissurlem mine site 183

Annexure 3.9 General standards for discharge of effluents 184

CHAPTER5 201

Annexure 5.1. Recommended trees for the dumps 267

List of Figures

Figure 1.1. Conceptual framework for AEQM . . . 4
Figure 2.1 Goa, talukas and study area . . . 17
Figure 3.1 Rainfall for North Goa . . . 61
Figure 3.2. Rainfall in South Goa . . . 61
Figure 3.3. Wind-rose diagram for North Goa . . . 62
Figure 3.4. Wind-rose diagram for North Goa . . . 63
Figure 3.5. Wind-rose diagram for North Goa . . . 64
Figure 3.6. Wind-rose diagram for North Goa . . . 65
Figure 3.7 Wind-rose diagram for North Goa . . . 66
Figure 3.8 Wind-rose diagram for North Goa . . . 67
Figure 3.9. Wind-rose diagram for South Goa . . . 68
Figure 3.10. Wind-rose diagram for South Goa . . . 69
Figure 3.11 Wind-rose diagram for South Goa . . . 70
Figure 3.12 Wind-rose diagram for South Goa . . . 71
Figure 3.13 Wind-rose diagram for South Goa . . . 72
Figure 3.14. Wind-rose diagram for South Goa . . . 72
Figure 3.15 Land use - Cluster I . . . 78
Figure 3.16 Land use - Cluster II . . . 79
Figure 3.17 Land use - Cluster III . . . 80
Figure 3.18 Land use - Cluster IV . . . 81
Figure 3.19 Dump reclamation - Cluster I . . . 94
Figure 3.20 Dump reclamation - Cluster II . . . 95
Figure 3.21 Dump reclamation - Cluster III . . . 96
Figure 3.22. SPM concentration - Cluster I . . . 101
Figure 3.23. SPM concentration - Cluster II . . . 102
Figure 3.24 SPM concentration - Cluster III . . . 103
Figure 3.25 SPM concentration - Cluster IV . . . 104
Figure 3.26 Air quality index - Cluster I . . . 115
Figure 3.27 Air quality index - Cluster II . . . 116
Figure 3.28 Air quality index - Cluster III . . . 117
Figure 3.29 Air quality index - Cluster IV . . . 118
Figure 3.30. Air quality and population density - Cluster I . . . 119
Figure 3.31 Air quality and population density - Cluster II . . . 120
Figure 3.32. Air quality and population density - Cluster III . . . 121
Figure 3.33 Air quality and population density - Cluster IV . . . 122
Figure 3.34 Water resources and mining activities - Cluster I . . . 130
Figure 3.35 Water resources and mining activities - Cluster II . . . 131
Figure 3.36 Water resources and mining activities - Cluster III . . . 132
Figure 3.37 Water resources and mining activities - Cluster IV . . . 133
Figure 3.38 Location of map showing observation well network . . . 160
Figure 3.39 Water-table elevation map above msl (April 1997) . . . 161
Figure 3.40. Water-table elevation map considering water levels in the mine pits at Pissurle and Kunde to be at Zero msl . . . 162

Figure 3 41 Villages affected by mining activities - Cluster I 167
Figure 3 42. Villages affected by mining activities - Cluster II 168
Figure 3.43. Villages affected by mining activities - Cluster III 169
Figure 3 44. Villages affected by mining activities - Cluster IV 170
Figure 5 1. Schematic diagram for pit water treatment under Scheme - I 219
Figure 5.2. Filtration unit for Mld treatment capacity Scheme - II 220
Figure 5.3. Scientific diagram for workshop effluent 224
Figure 5 4 Dump profile design when space is limited 227
Figure 5.5. Restoration philosophy 228
Figure 5.6. Progressive reclamation of dump 229
Figure 5 7. Reclamation of old dumps through revegetation 231
Figure 5 8. Alternative road for ore transportation in South Goa 241
Figure 5.9. Annual cash flow 251
Figure 5.10 Reclamation method for mined out benches 252
Figure 6.1 Existing institutional linkages and responsibilities for different departments in Goa 280
Figure 6 2 Proposed institutional linkages for Goan mining industry 282

List of Photographs

Photo No.1. Steep dump slope need to ensure terrace dumping ... 149
Photo No.2. Unplanned dump affecting forest area ... 149
Photo No 3. Steep dump slope - major cause for silt runoff ... 150
Photo No.4 Unmanaged dump with rills and gullies formed due to rainfall ... 150
Photo No 5 Silt deposition in agricultural field ... 151
Photo No.6 Wide and deep cracks in silted agricultural fields ... 151
Photo No.7. Ore loaded uncovered trucks: major source of dust pollution ... 152
Photo No.8. Steep benches formed during mining ... 152
Photo No 9 Pit water in operating mine ... 153
Photo No.10 Worked out mine pit suitable for development of recreation pond ... 153
Photo No.11. Impacted nallah due to mine water discharge ... 154
Photo No.12. Laterite filter wall to arrest silts in runoff ... 154

Abbreviations

AEQM	-	Areawide Environmental Quality Management
AQI	-	Air Quality Index
BOD	-	Biochemical Oxygen Demand
Ca	-	Calcium
CEC	-	Cation Exchange Capacity
CO	-	Carbon monoxide
COD	-	Chemical Oxygen Demand
CPCB	-	Central Pollution Control Board
CPM	-	Critical Path Method
Cu	-	Copper
dbh	-	diameter at breast height
DO	-	Dissolved oxygen
DPSE	-	Department of Planning, Statistics and Economics
DWT	-	Dead Weight Tonnies
EC	-	Electrical Conductivity
EMP	-	Environmental Management Plan
Fe	-	Iron
GIS	-	Geographical Information System
GSI	-	Geological Survey of India
ha	-	hectares
IBM	-	Indian Bureau of Mines
K	-	Potassium
Km	-	kilometres
L & T	-	Lurson & Turbo
m	-	metre
m.p.	-	measuring point
m.s l.	-	mean sea level
Mg	-	Magnesium
MGD	-	Million Gallens per Day
MMRD	-	Mines and Minerals Regulations and Development Act
MOEF	-	Ministry of Environment and forests
MPN	-	Most Probable Number
Mt/a	-	Million tonnes/annum
Mt	-	Million tonne
N	-	Nitrogen
Na	-	Sodium
NBSS&LUP	-	National Bureau of Soil Survey & Land Use Planning
NO_x	-	Oxides of nitrogen
NSDP	-	Net State Domestic Product
NTU	-	Nephelometer Turbidity Unit
OC	-	Organic Carbon
P	-	Phosphorus
Pb	-	Lead
PERT	-	Programme Evaluation Review Technique
PWD	-	Public Works Department

R/P	-	Reserve/production
RPM	-	Respirable particulate matter
SO_2	-	Sulphur dioxide
SPM	-	Suspended Particulate Matter
Sq-km	-	Square Kilometer
SS	-	Suspended Solids
TDS	-	Total Dissolved Solids
TISCO	-	Tata Iron & Steel Company
TSS	-	Total Suspended Solids
USDA	-	United States Department of Agriculture
WHC	-	Water Holding Capacity
$\mu g/m^3$	-	Microgram per cubic meter

Executive Summary

An area-wide environmental quality management (AEQM) plan for the mining belt of Goa has been prepared to assess the impacts of mining and other related activities on the environmental quality of the area and to structure a set of management strategies to improve it. The area studied covered approximately 520 sq km. with an estimated population of about 1 lakh inhabitants. The area is characterized by large scale iron ore mining operations, which have existed for many years and have resulted in widespread environmental degradation. The major reasons for deterioration are increased levels of iron ore mining over the years, an increase in population and lack of adequate control measures. The main findings have been organized in four categories- present conditions, future conditions and management strategies institutional dimensions and conclusions and recommendations

Present environmental condition

The present activities have created a very degraded environment. Evidence of land, air and water pollution is apparent in most parts of the area affecting the population. Air quality is affected in mines and surrounding villages due to high concentration of suspended particulate matter (SPM). Wastewater and runoff from dumps containing both dissolved and suspended solids pollute the rivers, stream and nallahs throughout the year and is the dominant pollution source of the surface water. Since the ore to overburden ratio ranges from 1:2.5 to 1:3 for Goan mines, large quantities of waste material is generated per tonne of iron ore mined. A total area of 3350 ha of land is under mining and associated activities of which 1300 ha is under dumps

Air quality

Major air quality problems exist in the mining villages and road corridors in the study area. Out of 57 villages in the in the study area, 12 villages are affected due to poor/bad air quality. In many locations, SPM concentration exceeds standards but Sulphur dioxide (SO_2) and oxides of nitrogen (NO_x) are well within the limits. The reasons for high SPM are.

- Fugitive dust caused by the movement of vehicles in opencast mines, mine roads and public roads
- Fugitive dust from dry screening plants, and
- Fugitive dust from loading stations on the river banks

Water quality

Major water quality problems occur in stretches of Bicholim, Madei and Khandepar rivers and Sonshi, Advoi, and Cudenm nallahs. These arise from the discharge into the river of both dissolved and suspended solids in untreated or partially treated mine water and beneficiation plant discharge water. In addition, runoffs from dumps result in siltation of river/nallah

stretches and agricultural lands

Solid wastes

Solid waste dumps (over burden and sub-grade ore) associated with mining are concentrated in the mining villages especially in Cluster II and III. These waste dumps and sub-grade ore dumps occupy large land surfaces in the mining areas. In addition, pits, roads, beneficiation plants and tailings pond also occupy large tracts of land.

Socio-economic situation

The socio-economic survey has identified many issues that are of concern to the villages, the most important among them being scarcity of water in some villages especially during the summer months. Another important factor is the lack of any other industrial activity in the area resulting in very little scope for alternate employment opportunities

Future plan of activities

A time period of 15 years has been chosen for the future projections (1997-2012) The economic growth in the study area will continue to be dominated by mining and associated activities. The iron ore production would remain at a level of 14-15 Mt per annum Closure of mines in some leases has been projected but the loss in output is assumed to be made up from expansion of activities in other leases. Therefore, the impacts on the environment would increase in these villages. The peoples opinions on the future of mining was also assessed through the socio-economic survey The people, in general, do not like increased mining activity in their areas Unless alternate economic activities are planned for the area, increased unemployment will be the outcome of reduced mining activity affecting the economic well-being of the population.

Under the business-as-usual scenario, which assumes that the companies would continue to adopt control measures as being practiced at present, it is expected that the environmental quality of the area will deteriorate further due to mining activities It is clear that additional control measures are necessary to improve the status of environment in the area and therefore, a number of management strategies are proposed.

Management Strategies

MS-1

Management strategy-1 confirms the need for additional abatement measures in addition to the current measures being adopted by the companies. The net benefits are as follows

- Decline in TSS in pit discharge water is expected due to improved measures for settling of solids which include settling tanks, use of coagulants, filter beds and check dams. In addition, closed water circuit in beneficiation plants would result in reduced water requirements and low or nil discharge of solids into water bodies.

- The quantity of waste material (overburden) due to mining is expected to remain more or less at the same level, but the net disturbed land under dumps is reduced from 830 ha to about 300 ha due to enhanced reclamation of damaged land.
- The tailings discharge from beneficiation plants would continue but tailing ponds would be rehabilitated.
- Air quality improves significantly and the AQI in all villages is estimated as good. Therefore, the number of households exposed to high levels of SPM would be almost negligible

MS-II

With improvements in mine roads and public roads and implementation of all dust control measures listed under MS-I, there would be a drastic reduction in generation of fugitive dust resulting in reduction in SPM levels along the road corridors. The alternative (new) roads for ore transport from South Goa mines would result in reducing dust levels significantly in the 3 towns - Curchorem, Sanvordem and Capxem. In addition, the ore traffic load on the existing roads would decline, resulting in less congestion and accidents on the roads

MS-III

The measures under this strategy would greatly help in improving the quality of life of the people in the mining villages The use of pit water for drinking after initial treatment at the mine and secondary treatment at a central location adjacent to the villages would reduce the water scarcity conditions in some villages during summer months Vocational training institutes would help to upgrade the skills of the villagers opening up more employment opportunities Another major advantage is the improvement in the company's image due to their involvement in community development activities in villages surrounding the mines.

MS-IV

Management strategy IV is a combination strategy incorporating elements from all three strategies In effect if these elements are introduced into the mining belt, than what is obtained is integrated environmental management of the mining belt and the parallel concept of planning for closure from the outset of operations For those mines, as is the case in this study, that are well into their project cycle it implies adopting an integrated approach from the point of entry up until the closure of the mine. Such an approach will ensure that mineral development remains competitive while contributing to the sustainable development of the region

Cost estimates

The total investment is estimated at Rs 4500 lakhs for abatement measures in MS-I, Rs 11500 lakhs for improved roads and an additional Rs 4200 lakhs for alternate (new) roads under MS-II, and Rs 3275 lakhs for welfare measures under MS-III. Four control measures, namely,

land rehabilitation, dust control, road improvement, and pit water treatment for drinking water supply, constitute the bulk of the investments The impact of the cost of abatement measures under MS-I is Rs 7/- tonne of ore production and this cost should be absorbed by the mining companies. However, the rehabilitation of old waste dumps and abandoned mines and de-silting of stretches of rivers/streams affected due to past mining operations should be the responsibility of the government. The cost of these measures can be estimated only after a physical survey of the affected areas. This could be funded from the royalty fund being collected by the government.

Road improvements (MS-2) could be funded through a road cess on iron ore of Rs 14/t and welfare measures implementation (MS-3) can be funded through a social cess of Rs 5/tonne of the ore production. The net result of all these measures would be a substantial improvement in the quality of environment in the area. In addition, supply of drinking water to affected villages and provision of sanitary and education facilities and development of economic activities in the mining areas would improve the quality of life of the population

The impact of the total cost of all these measures taken together (which can be taken as MS-4) is estimated at Rs 26/- tonne of ore production. If we assume that the average cost of iron production is Rs 300/tonne, the impact will be 8.6% of the production cost

Better environment and improved welfare amenities may improve the productivity of the persons employed in the mines resulting in financial benefits to the company. Improved roads, apart from improving environment would result in less congestion and accidents and increased economic activity for the state.

Recommendations

For a successful AEQM study and its implementation it is of utmost importance that the major players actively participate in providing data and help to formulate realistic abatement measures in terms of costs and feasibility. Formulation of management strategies is fundamental to the AEQM method and this cannot be independently developed by the AEQM study team

In spite of major problems like lack of data on emissions generation and discharge and future projections of iron ore production, etc , an attempt has been made to quantify the impacts, future production, cost of abatement measures under each management strategy. Cost data used in the analysis are rough estimates, especially for road improvements and welfare measures. An independent agency, MADA (Mineral Area Development Authority), under the department of industry and mines has been suggested to co-ordinate with various government and other agencies and be fully responsible for implementation of the AEQM plan Funds for implementation is to be raised from royalty and various cesses proposed on iron ore.

Another major factor in implementing the plan are the political considerations. The following aspects need to be considered when presenting the plan to administrative authorities.

- Priorities of environmental problems in relation to other societal problems.
- Priorities of strategies within the AEQM plan.
- Inter-governmental relations (center-state and state-district).
- Public acceptance.
- Obtaining the legal authority for the institution entrusted with implementation.

In the AEQM plan various abatement measures have been included under the different strategies. In addition the major recommendations are as follows:

i. Implementation of abatement measures in the operating leases/mines should be the responsibility of the mining companies.

ii. The rehabilitation of abandoned pits and dumps and desilting of stream and nallahs due to past mining activities should be the responsibility of the government and can be implemented through the forest and irrigation departments.

iii. Studies are required to generate baseline data and information on runoff, soil erosion and siltation. These studies would help in designing cost effective control measures. In addition they may help in dispensing with the system of arbitrary payment of compensation to farmers whose fields are silted in various degrees. A proper scheme, based on data, can be designed for loss in agricultural output and amount of compensation to be paid.

iv The villages facing acute shortage of water for domestic needs have been identified. A detailed survey should be carried out to identify the mines for supply of pit water to these affected villages for domestic needs The suggested form for treatment of pit water is the use of granulated activated carbon (GAC) treatment. A pilot study is recommended for detailed designing of GAC column and to decide the frequency of reactivation.

v It is important that the ground water studies on individual catchments in the entire mining belt of Goa should be carried out. This would help in preparing action plans for each micro-catchment level for implementation. In addition, the following studies are also recommended to assess the impact on ground water.

  - Estimation of actual ground water withdrawals from mine pits on micro-catchment basis, using gauging methods and computation of recharge to ground from river beds and agricultural lands during non-rainy seasons.
  - Aquifer parameter estimation both for shallow and deep aquifers through pump tests at representative locations.
  - Development of ground water models for mining areas to assess impacts due to future operations.

vi The improvement of mine and public roads should be taken up by the government. In addition, alternate (new) roads suggested by the Committee should also be finalised and taken up for construction by the government. The cost of road construction/improvement will have an impact of Rs 14/tonne of ore production if the total cost is charged on iron ore production. The cost can be recovered from the

companies in the form of a road cess. The government can decide as to how much of this cost has to be borne by the companies so that part of the expenditure is met from the government budget for roads.

vii. The task of improving welfare measures in the mining and other villages in the area should be the responsibility of the government and the mining companies. A social cess of Rs 5/tonne of ore is recommended to meet the proposed expenditure.

viii. Ambient environment quality monitoring of the area should be the responsibility of MADA to generate base-line data on air, water, soil, land, ecology, etc. and for initiating corrective actions wherever required.

ix. R&D experiments for upgrading the quality of Goan ore and value addition to the ore should be undertaken by MADA. In this connection, the scope of cost effective pelletization of Goan ore can also be examined.

x. Merger of adjacent mining leases for more efficient operation resulting in improved economics and environmental control should be promoted.

xi. Setting up of small and medium industries for agro-based products, building blocks from waste overburden material, engineering units, etc. should be promoted. In addition, dairy development projects in mining villages can be encouraged.

xii. An integrated strategy (MS-4) will ensure that mineral development remains competitive while contributing to the sustainable development of the region.

CHAPTER 1

Introduction, objectives and methodology

Background

Industrialization has contributed immensely to the economic development of the world, but in its wake has caused environmental degradation. Since humans have to live within their environment, the process of development should be sustainable so that environmental quality is maintained within safe limits The value of emphasizing sustainability is essentially to integrate industrial development and environmental management in the development process. It is only through an integration effort of the environmental aspects into the planning and management of industrial development that significant progress towards a sustainable society can be made. Solutions to the complex inter-related problems implicit in sustainability requires a holistic approach that is beyond the interest of individual economic interests and single function environment agencies

AEQM concept

Areawide environmental quality management (AEQM), is a holistic approach to spatial environmental planning applicable to a specific region It assesses the impacts of industrial and other human activities on environmental quality and structures a set of management strategies that reflect environmental, economics, technology and institutional considerations. These strategies, in turn should lead to actions by government, industry and public. The "Policy Statement for Abatement of Pollution" issued by the Ministry of Environment and Forests (MoEF), Government of India encourages the use of a mix of instruments in the form of fiscal and financial incentives, legislation and regulation, voluntary agreements, educational programmes and information campaigns to achieve the objectives of an AEQM.

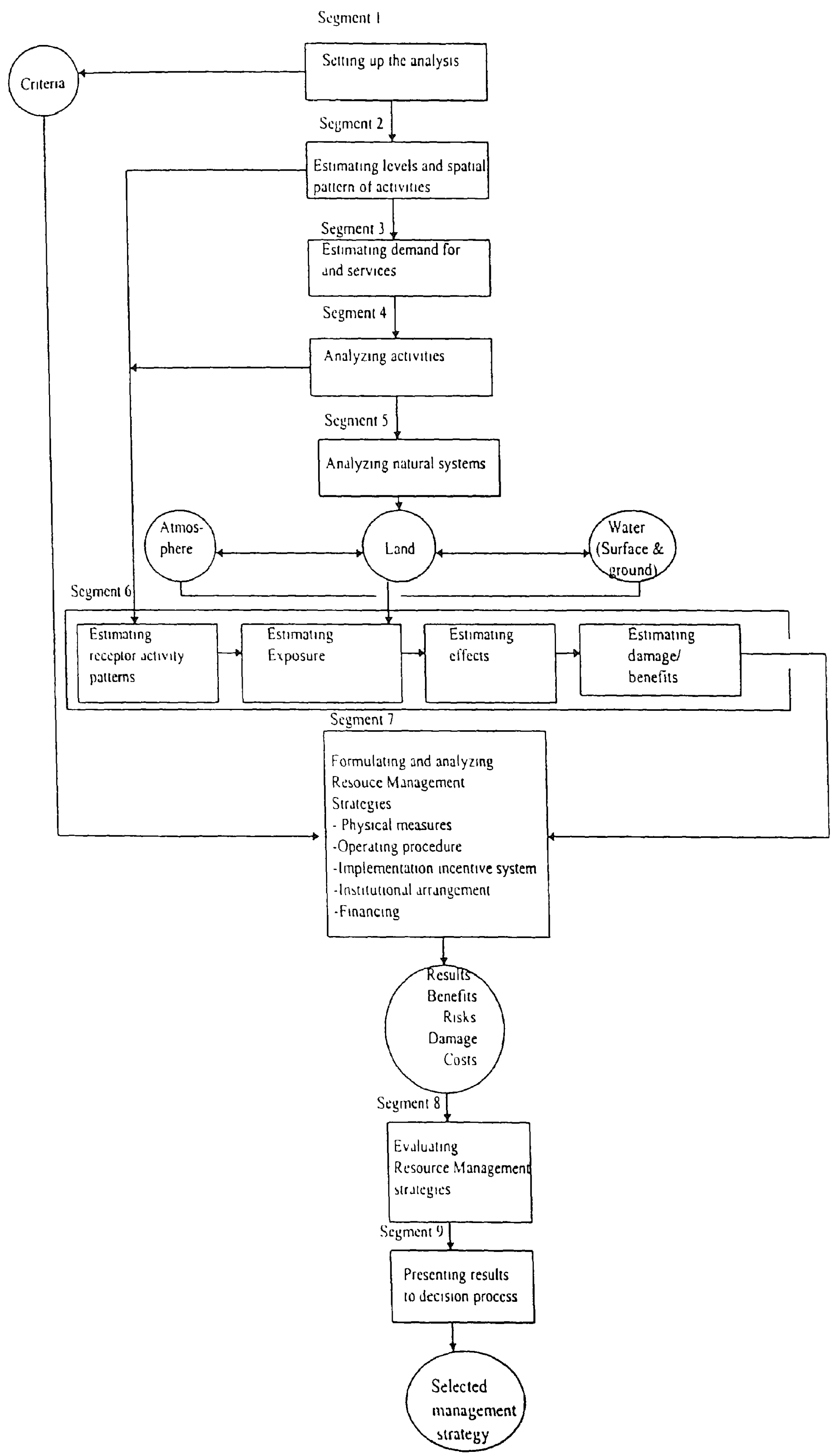
The AEQM approach is a powerful problem solving technique for a wide range of environmental situations because it integrates concepts from the fields of ecology, environmental management, technology assessment, economics and political science to identify and evaluate alternative environmental management strategies While most of these concepts are not difficult to understand, successful completion of an AEQM study may be quite challenging. The need for interdisciplinary analysis stitches many people and organizations, particularly where data is limited, which is often the case in environmental investigations.

A basic understanding of the approach may be achieved by focussing on the computational framework used to generate information for AEQM decisions. A computational framework is a set of analyses, either formally linked by an algorithm, or linked in the sense that

the output of one or several analysis becomes the input into another analysis Thus, a computational framework can be thought of as analogous to a Critical Path Method (CPM) or Programme Evaluation Review Technique (PERT) diagram, either one representing a set of connected activities to produce an output in some specified time frame. The framework is presented in Figure 1.1 and is elaborated upon below:

- Segment 1: Setting up the analysis. Defining objectives, making an inventory of the present conditions and problems and developing scenarios for analysis.
- Segment 2: Estimating levels and spatial pattern of activities. Choose the target years, approximately (circa 2011-12) for this study, and make estimates of various human activities at that time, e.g. population growth, industrial production etc.
- Segment 3: Estimating demands for goods and services from the AEQM area, e.g. spatial estimates of the amount of iron ore that may be mined.
- Segment 4: Analyzing activities – e.g. analyze human activities that result in water and air pollution, land degradation.
- Segment 5: Analyze natural systems – e.g. model the spatial patterns of suspended particulate matter (SPM), associated with the transport activity previously studied in other segments.
- Segment 6: Estimating receptor activity patterns, exposures, effects, damages and benefits – e.g. damage of agriculture land due to siltation, exposure to high concentrations of dust in the AEQM area.
- Segment 7: Formulating and analyzing environmental management strategies. This would include pollution abatement measures such as rehabilitation of degraded land, reducing pond spills, preventing and controlling runoff from dumps as well as incentive systems for enforcing regulations, changed institutional arrangements and improved financing programmes.
- Segment 8: Evaluating environmental management strategies that would upgrade the general air, water and land environment under the impact of mining industry and population demands in order to improve the quality of life.
- Segment 9: Presenting results to the decision-makers in a way that would permit evaluation of the different management strategies and encourage decisions likely to improve environmental quality.

Figure 1.1 Conceptual framework for AEQM



State of Goa

Location and extent

Geographically, the State of Goa is located along the mid-west coast of India and is bound between the co-ordinates 14° 53' 57" to 15° 47' 59" N and 73° 40' 54" to 74° 20' 11" E Bordering the state towards the north is the Sindhudurg district of Maharashtra state, on the east Belgaum District (Karnataka) and to the south is the North Kanara district of Karnataka. On the west is the Arabian sea and the coast line stretches to a length of about 105 km in the State. Goa covers an area of 3700 sq km and has many physical features that are common to the neighbouring regions of Maharashtra and Karnataka.

Forests in Goa

Forest ecosystem in Goa, according to the latest land use classification (Government of Goa, 1995), occupy an area of 125,473 ha constituting over one-third (34.8%) of the total geographical area of the state; forestry being a major land use next only to agriculture (138,091 ha) However, the area officially recorded as forest, with or without tree cover, by the State Forest Department is 142,400 ha (39% of the total geographical area) of which 122,400 ha is Government forest and 20,000 ha is private forest (Government of Goa, 1995). The actual forest cover in the state, however, is of the order of 125,000 ha (Forest Survey of India, 1996). Almost 94% of the total forest area in the state is confined to the four Talukas of Sanguem (56,924 ha), Satari (28,099 ha), Canacona (18,581 ha) and Quepem (11,491 ha) while the three Talukas of Sanguem (56,924 ha), Satari (28,099 ha) and Bicholim (808 ha) contain about 70% of the total forest area.

Goa presents a wide range of altitudes, slopes, drainage which coupled with abundant rainfall and high humidity give rise to a variety of locality factors reflected in the occurrence of a number of forest types from tropical evergreen to mangrove forests. The coastal tracts with marine alluvium are mainly covered by palms. The border line of Arabian sea and the west coast are thickly palm-fringed with a small area covered by mangroves. Patches of scrub vegetation with other xerophytic species are found in association with tropical fruit trees like jackfruit and cashew. The forest types broadly represented in the state as per the revised classification (Champion and Seth, 1968) are as follows

1A C4	-	West Coast Tropical Evergreen Forest
E1	-	Cane Brakes
E2	-	Wet Bamboo Brakes
2A.C2	-	West Coast Semi-evergreen Forest
E3	-	Moist Bamboo Brakes
E4	-	Lateritic Semi-evergreen Forest

3B.C1.1c	-	Slightly Moist Teak Bearing Forest
3B.C2	-	Southern Moist Mixed Deciduous Forest
3B.2S1	-	Southern Secondary Moist Mixed Deciduous Forest
4B.TS1	-	Mangrove Scrub
4B.TS2	-	Mangrove Forest
5 E7	-	Laterite Thorn Forest
8A.DS1	-	South Indian Sub-tropical Hill Savannah (Woodland)
8A.C2	-	Western Sub-tropical Hill Forest.

Most of the mining areas in the state are confined to Laterite Thorn Forest type (5.E7) which consists of irregular open scrub of stunted trees of deciduous habit and thorny trees. The under growth is thin and xerophytic. Soils are dry and shallow with outcrops of laterite. At places the underlying laterite is soft and extracted for commercial purpose. Mainly the species of this type are *Terminalia paniculata*, *Careya arborea*, *Buchanania lanzan*, *Bridelia retusa*, *Lannea coromandalica*, *Strychnos nux-vomica*, *Randia dumatorum*, and *Phyllanthus emblica*.

However other important species like Shisham, *Terminalias*, bamboos, canes, *Xylia xylocarpa*, *Adina cordifolia*, *Lagerstroemia parviflora*, teak; *Rhizophora mueronata* are also found in the various forests types just mentioned.

Soil

Land and soils

The state is endowed with a wide range of physiography, landforms, geology and vegetation, which have influence on the genesis of the soils. Depending upon elevation, slopes and ruggedness of terrain, Goa has been divided into two major physiographic regions, viz., Konkan Coast and Central Sahyadri (NBSS & LUP, 1995). Based on relief and geology, Konkan coast, in turn, is subdivided into fluvio-littoral landform and dissected hilly landform. Central Sahyadri is subdivided into granite and granite-genesis landform, quovetsite/schistose land form and basalt land form.

The soil climate can be considered as "udic" moisture regime with soil temperatures as "hypothermic" since the difference of mean summer temperature and mean winter temperature is more than 5°C.

Nearly 2/3 of Goa is covered by laterite, ranging in thickness from a couple of meters to over 25 m. Generally the maximum thickness is observed along the west coast and minimum

along the ghat section in the east. The laterite is generally vermicular and cavernous and sometimes pisolitic.

In addition to the soils identified and described by the NBSS & LUP, Nagpur, there are rock outcrops and laterite crusts associated with the soils. The soil units associated with rock outcrops cover 0.25% while the soil unit with laterite crusts cover 4.4% of geographical area.

The soils of Goa have been classified according to Soil Taxonomy (Soil Survey Staff, 1992) by the NBSS & LUP in different orders, sub-orders, great groups and sub-groups, and in terms of percentage coverage of the total geographical area of the State along with their current land-use. According to this classification, soils of Goa belong to 4 orders, 7 sub-orders, 13 great groups and 16 subgroups. Amongst the different orders, Inceptisols occupying 68%, are dominant followed by Ultisols (13%), Entisols (8%) and Alfisols (6%).

Water resources

The State is drained by a number of rivers namely, Mandovi, Zuari, Tiracol and Chapora flowing westward into the Arabian sea. Of these Mandovi and Zuari are the major rivers flowing through the study area. The Mandovi originates in the main Sahayadris of Karnataka and its various tributaries, i.e. the Bicholim, Mapusa, Kudna, Khandepar and Madai rivers contribute directly or indirectly to its incharge. The Mandovi has the largest drainage basin in Goa. The Kushavati river is the major tributary of the Zuari. The river basins of Mandovi and Zuari cover about 69% of the total area of the State and are together called the "Life line" of Goa

Minerals

Goa is divided into two districts viz North Goa and South Goa, which are divided into 11 talukas spread over both these districts. The State is rich in minerals such as iron ore, manganese, bauxite and silica sand. At present iron and manganese are the major extractive industries. Mining is an important activity for the economy of Goa and a significant foreign exchange earner for the State Certain natural factors like the presence of coastline, a very good natural harbour at Marmagao and a number of navigable perennial rivers and streams have promoted the economic exploitation of these mineral deposits. The Mandovi and Zuari rivers, their tributaries and the Cumburja canal are key factors in maintaining the economic viability of Goan mines Transport of ore by barges is the cheapest option as compared to road and rail transport.

Mining belt of Goa

The mining belt of Goa, an area of approximately 700 sq. km. a little less than 20% of Goa's land area, is mostly concentrated in four talukas, Bicholim, Satari, Sanguem and Quepem. Mining and associated activities have considerably affected the landscape. The land area is characterized by pits and overburden dumps due to opencast mining. Runoff from these dumps are damaging croplands as well as causing siltation in many water bodies. Transportation of iron ore by trucks

has created a serious dust problem on some of the public roads. Settlements within the vicinity of these roads are exposed to high levels of dust. In many locations where the iron ore is found below the water table, it is necessary to extract large volumes of water. Despite the potential availability of the large volumes of water, some of these locations are experiencing water scarcity. It is in this context that the present study has been undertaken to identify and analyze the impacts of mining on the environment and devise strategies to mitigate the adverse environmental effects.

The AEQM study area

The granting of mining lease is controlled by the Department of Industry and Mines, Government of Goa. The mine plan including the environmental management plan for each mine is approved by the Indian Bureau of Mines (IBM), Government of India. The Forest Department, Government of Goa is involved in clearance of forest areas for mining and permission of Ministry of Environment and Forest, Government of India is obtained in each case.

The mining belt has been defined for this study as the region comprising those villages which have working iron-ore mine leases and which through prior investigation have been deemed affected by mining activity. These villages are 57 in number, and fall in three talukas of Bicholim and Satari in North Goa District and Sanguem in South Goa District. Eighty per cent of the working mine leases are found in these three talukas. These mines are found in distinct conglomerations. Iron ore mining in Quepem taluka is negligible and hence has not been covered in the study area. By considering the spatial continuity/non-continuity and working/operational status, it has been decided to divide the iron ore mining areas in the above three talukas into four clusters. These are Cluster I, II, III and IV. The villages included in the study area are based on the following:

- Villages where actual iron ore production is ongoing.
- Those villages which are lying between the working mines and major rivers/streams.
- Villages that have reported agricultural output loss due to impact of mining.
- Villages having ore beneficiation plant and/or barge loading points.

The cluster-wise list of study villages is enclosed as Annexure 1.1.

Objectives and terms of reference of the study

The objective of the study is to devise an AEQM plan for the mining belt of Goa. The AEQM plan may guide the activities of the Government of Goa in its efforts to reduce environmental degradation in the mining belt. The AEQM strategy would be characterized by cost effectiveness, persuasiveness, implementability, and innovativeness. The AEQM plan would cover a period of

15 years (1996-1997 to 2011-2012, hereafter 1997 to 2012). The terms of reference for the preparation of AEQM plan for the mining belt of State are given below:

- A detailed study of environmental and socio-economic situation, present conditions and problems vis-a-vis various developmental programmes needed in the mining belt.
- Formulating and analyzing environmental quality management strategies and evaluating these management strategies for their cost effectiveness and implementability in the mining belt.
- To suggest a detailed approach to be followed by the Government as regards to ecology, transportation, waste disposal, technology, etc. as well as the institutional and administrative arrangements required for its implementation and monitoring from time to time.
- To suggest a time bound action plan and estimation of funds required for effective implementation of these strategies.

Methodology/Approach

The methodology for AEQM includes a computational frame work that may be used to organize the investigation leading to management decisions for solving important environmental problems. The framework presented in Figure 1.1 contains the basic features of the approach

The data assembled for the various segments of the computational framework are organized within four primary land areas, namely, mining clusters. These are subdivided into smaller areas, namely, 57 villages for more detailed analysis. Therefore, in this study a village is taken as the basic unit for analysis.

By and large, the approach described in the framework would be followed, although improvisations would be necessary due to data limitations A major problem would be estimating the generation of identified pollutants from many sources For example, SPM emitted from open-cast mines, from dumps and roads cause significant air pollution in some location but may be extremely difficult to quantify. Similarly, the run-off of storm water from waste dumps would be difficult to quantify. In order to accomplish the objectives of the study, it is imperative to understand the land use/land cover characteristics and the changing pattern over the years Besides, it is also important to locate the mine pits, over burden dumps, beneficiation plants, tailing ponds and loading points in the spatial context to study the area wide environmental impact. The remote sensing data products and Geographical Information System (GIS)are handy tools to carry out this task.

The present study made use of aerial photographs and satellite imageries in order to study the land use/land cover changes over the years in conjunction with the Survey of India topographic sheets at 1:25,000. The stereoscopic interpretation of black and white aerial photographs at 1:10,000 scale (approx.,) has been carried out in order to study the land cover conditions in all the four clusters in the year 1988. The changes after this have been studied

through the visual interpretation of black and white geocoded satellite imageries of 1997 at 1:12,500 scale.

In order to demarcate the study area (i.e. the four clusters) in aerial photographs, a loose mosaic of alternative photographs were made. With the help of flight line map and cluster maps the study area has been demarcated. The stereopairs were studied strip-wise under mirror stereoscope to demarcate the land cover features. The land cover denotes the natural and artificial features that covers the land surface. These features are demarcated based on tone, texture, size, pattern, association and also through the visual interpretation keys developed after field observation. The stereoscopic interpretation has helped to identify and delineate the land cover features in the area.

Organization of the study

A field office has been opened in Goa to help in organizing the study. The TERI team worked closely with various State Government departments, Indian Bureau of Mines, mining companies, GMOEA and University of Goa. Preliminary visit of the study area were made in October 1996. Subsequently, monthly visits were made for data collection and discussions with concerned authorities. The following activities have been carried out:

- Preparation of cluster-wise base maps, interpretation of aerial photographs (January 1988) and interpretation of geocoded satellite imageries of IRS-IC Panchromatic Sensor (January - April 1997).
- Detailed socio-economic survey in 23 villages.
- Collection of data on production, ore transportation, loading, beneficiation plants, environmental quality, etc.
- Development of an air quality index and preparation of village wise inventory of air quality status.
- Assessment of surface and ground water quality in mines and surrounding villages.
- Assess the impact of mining on ground water in a small river catchment in the mining belt.
- Assess the quality of soil and problems of run off and siltation from the mines.
- Visit to different afforestation sites in mine areas for collecting information on plantation.

Database and sources

This study has made use of various data pertaining to mining, air quality, water, forest, soil, land use and population from a wide range of sources as described below.

Data on mining

The mining related data on ore reserves, production, dumps, loading points, capacity, ore export, have been collected from GMOEA, Department of Mines (Government of Goa), IBM (Nagpur and Goa), mine plans and mining companies.

Water

The water quality and sediment data of rivers and streams has been collected from IBM (Nagpur), Environment Week Reports, G.N. Nayak reports, questionnaire survey of mining companies whereas the impacts have been assessed through interpretation on satellite imageries. The ground water fluctuations have been studied by monitoring water levels in dug wells in sample villages.

Air

The air quality data was collected from IBM, Nagpur and Goa and environmental week reports prepared by individual companies in Goa and through questionnaire survey.

Population

The demographic information has been collected from District Census Handbook - 1991 of Census of India and also through a primary socio-economic survey of selected villages.

Land use

The land use pattern for 1988 has been obtained from the aerial photographs (1988 January) interpreted maps. These aerial photographs and their interpretation facilities are provided by Town and Country Planning Department (Government of Goa) The land use pattern for 1997 has been obtained from the satellite imagery interpreted maps The geocoded satellite imageries of IRS-IC Panchromatic sensor for 1997 (January-April) at 1:12,500 has been procured from National Remote Sensing Agency (NRSA), Hyderabad to map the land use pattern.

Soil

The soil quality has been studied through the analysis of soil samples collected from sample sites and also from the data collected from IBM (Nagpur) and other studies

Annexure 1.1. Cluster wise name of study villages

Cluster I

Bicholim Taluka

1 Adwalpale
2 Sirigao
3 Mulgao
4 Sarvona
5 Maem
6. Carapur
7 Piligao
8 Aturli
9 Vainguinim
10. Ona
11 Lamgao
12. Naroa
13. Bicholim

Cluster II

Bicholim Taluka

1. Cassabe de Sanquelim
2 Arvalem
3 Cudnem
4. Surla
5 Velguem
6 Pale
7 Virdi
8 Navelim
9 Maulinguem South
10 Cotombi
11 Amone

Satari Taluka

12 Pissurlem
13 Sonshi (Sonus-vonvoliem)
14 Vaguriem
15 Advoi
16 Onda
17. Vantem
18. Birondem

19. Codiem
20. Ponocem
21. Cumarconda

Cluster III

Sanguem Taluka

1. Darbandora
2. Sancordem
3. Sigao
4. Sangod
5. Cormonem
6. Codli
7. Bandoli
8. Santona
9. Calem
10. Dudal
11. Costi
12. Coranginim
13. Comproi
14. Muguli
15. Camarconda
16. Rumbrem
17. Sanvordem
18. Antonem
19. Moissal

Cluster IV

Sanguem Taluka

1 Patiem
2 Tudou
3 Potrem
4. Bati

CHAPTER 2

Present economic and social conditions

This chapter discusses mining activity from a socio-economic perspective. It sets it in the context of the Goan economy and discusses both the activity and the agents. This is important in order to understand the room to manoeuvre for both the government and mining companies.

Economic scenario of the State

The Goan economy is very much a developed economy in the sense that the tertiary sector dominates its economic structure, followed by the secondary and the primary sector. The shares of sectoral income over the period 1980/81 to 1994/95 are presented in Table 2.1. The decline in shares of the primary and secondary sectors and the increase in that of the tertiary sector is evident. The tertiary sector dominates the economy with over 45% of the Net State Domestic Product (NSDP) originating in this sector. In 1994/95, agriculture contributed 11.4% of NSDP; the mining and quarrying industry 7.7%, the tourism industry 13.7% of NSDP, financial and other business services about 11% and, community, social, and personal services about 12%. Agriculture dominates the primary sector, while registered manufacturing dominates the secondary sector with about 21 6% of NSDP.

Table 2.1. Sectoral share of Net State Domestic Product (NSDP) (in %)

Year/Sector	Primary	Secondary	Tertiary	Total
1980-81	28 5	29 7	41 8	100
1984-85	26 1	30 4	43 5	100
1990-91	21 7	30 4	47 9	100
1994-95	22 6	30 9	46 5	100

Source Government of Goa
Estimates of State Domestic Product, 1994/95

Role of mining in the state economy

Mining has been a very important element of the economic history of modern Goa. It started in 1950s and has played a key role both in the economic numbers and in the local lore. The importance of mining and quarrying to the net state domestic product has, however, been falling over the last 25 years. In 1970/71, the share of income from the mining sector was 11.7%; in

1980/81 it had fallen to 5 5% and further to 4.7% in 1990/91.This trend has changed since 1990/91, with the sectoral contribution rising over the last 5 years to 7.7.% in 1994/95 as shown in Table 2.2.

Table 2.2. Contribution of the mining industry to NSDP (1970-71 to 1994-95)

Year	% share of NSDP
1970/71	11 7
1980/81	5 5
1990/91	4.7
1991/92	5.2
1992/93	5.4
1993/94	7.9
1994/95	7 7

Source: Government of Goa

Export earnings from iron ore

Annual production of iron ore in Goa, which has been averaging about 13 Mt in the early 1990s showed an increasing trend in 1994-95 and 1995-96 and reached a high level of 17.2 Mt in 1995-96. In 1996, the production declined to 13.8 Mt. All of Goa's iron ore production is exported. At present there is no local market for its low grade ore. In terms of exports, Goan ore represents over 60% of India's exports. At the time of liberation in 1961, iron ore exports accounted for Rs.18.31 crores and this has been rising steadily and reached Rs 614 crores in 1995-96. The value of ore exported from Goa is now roughly equal to the tax and non-tax revenues of the Goa Government which for 1996-97 is estimated at Rs 700 crores, pointing to the importance of the industry to the economy of Goa (Almeida, 1997). In order to comply with export specification, the ore from Goa is beneficiated, and is used for blending by foreign steel mills with higher grade ore imported from other countries The destination wise share of exports is as follows· Japan 56%; Europe 21%; South Korea 10% China 9% and others 4%. The high dependence of exports on the Japanese market is evident. The main competitors to Goan exports to Japan are Australia, and Brazil. The Goan ore exporters have, for the last 20 years operated totally in a buyers market The price for them is fixed as they are very small operators having only 5% of the Japanese market. The steel mills through the trading houses enter into direct quantity contracts with the producers with a clause that provides for reduced or expanded offtake by the buyer. No such option is given to the seller. Moreover, they have to meet the stringent specifications of the buyer, as the ore is used to blend with the high quality ores imported from other parts of the world. The details of production and export are given in Table 2.3.

Table 2.3. Quantity and value of iron ore exported from Goa, 1990-91 to 1996-97

Year	Iron ore production (Mt)	Quantity of ore exported (Mt)	Goa's contribution to India's export of iron ore (%)	Value of ore exported (Rs. crores)
1990-91	13.55	12.72	37.60	309
1991-92	12.51	11.65	39.29	428
1992-93	12.03	12.79	57 68	531
1993-94	13 10	15.12	56.29	588
1994-95	15 11	14 71	56 43	532
1995-96	17 18	14 49	60 00	614
1996-97	13 78	14 14		700*

Source GMOEA (1997)

* Estimated

Royalty payment to the state government

The state government collects a royalty on ore despatched (exported) at a rate depending on the grade and type of ore. The average rate was Rs.7/tonne in the last three years. It has been increased to Rs. 9/tonne since April 1997. The annual royalty payment to the State Government ranges from Rs 9.20 crores to Rs 9 50 crores in the last 3 years which is about 1.5 per cent of its export value.

Local economy

The domestic economic product of the four talukas namely, Bicholim, Satari, Sanguem, and Quepem were estimated in order to arrive at the relative importance of mining to these talukas. The analysis revealed that the income generated in the iron ore mining belt is very important to the economy of Sanguem and Bicholim talukas, relatively less important to Satari and not important to Quepem. Mining activity has certainly provided the trigger to boost the economies of the mining talukas and put them on to a higher level of economic activity. The average annual growth rate over the 20 year period (1970/71 to 1990/91) for the mining talukas is as follows: Bicholim 7 9%, Satari 10%, Sanguem 6%, and Quepem 7.1%. Within the mining belt, considerable diversification has occurred as is evident in the declining share of mining income over the last 20 years as given in Table 2.4.

Table 2.4. Sectoral shares of total income of the mining belt (%)

Sectors	1971	1991
Agriculture	23 6	25 9
Forest and Fishing	2 9	5 9
Mining & Quarrying	54 9	14.5
Secondary	12 9	26.9
Tertiary	12.9	26.8

It is evident from the Table 2.4 that agriculture has maintained its hold over the total income, this despite the fact that there has been a decline in the land under cultivation in the mining region. The adoption of high yielding variety seeds explains in part the unchanged contribution of agriculture to regional income. The steep increase in income from the secondary sector is related to mining activity, especially the economic activity such as servicing and repairs of trucks which are carried on in the household sector. Income from the transport sector too has gone up considerably and is again connected to mining activity.

Economic activities in the study area

Mining

The mining belt is divided into three regions based on the concentration of iron ore: the Northern zone, the Central zone and the Southern zone, Usgao river is the dividing line between the northern and the central zone and the Sanguem river between the central and the Southern zones. The maximum area under mining leases is in Sanguem taluka followed by Bicholim, Satari, and Quepem. An analysis of the surface area utilization of these 4 talukas reveals that in Sanguem, forest area occupies the largest area; while in Bicholim, cultivated and orchard lands occupy the highest. Over the last 30 years, North Goa has dominated iron ore production; but the trend is changing with a larger share of production coming form the central and southern zones.

For purposes of this study, the mining belt has been divided into four clusters covering 55 villages, and two census towns falling under three talukas, namely, Bicholim (22 + 2 towns), Satari (10), and Sanguem (23). Figure 2.1 gives the map of Goa showing all the talukas and the study area (see Annexure 1.1 for names of villages) Annexure 2 1 gives area and population of villages and towns covered in the study. The area and population of clusters in relation to the talukas is given in Table 2 5 It can be seen from the table that the study covers 39% of the land area and 45% of the population in the three talukas. Mining activity is most dominant in the Bicholim taluka where it covers 58% of the land area and 63% of the population A brief description of the clusters is given below

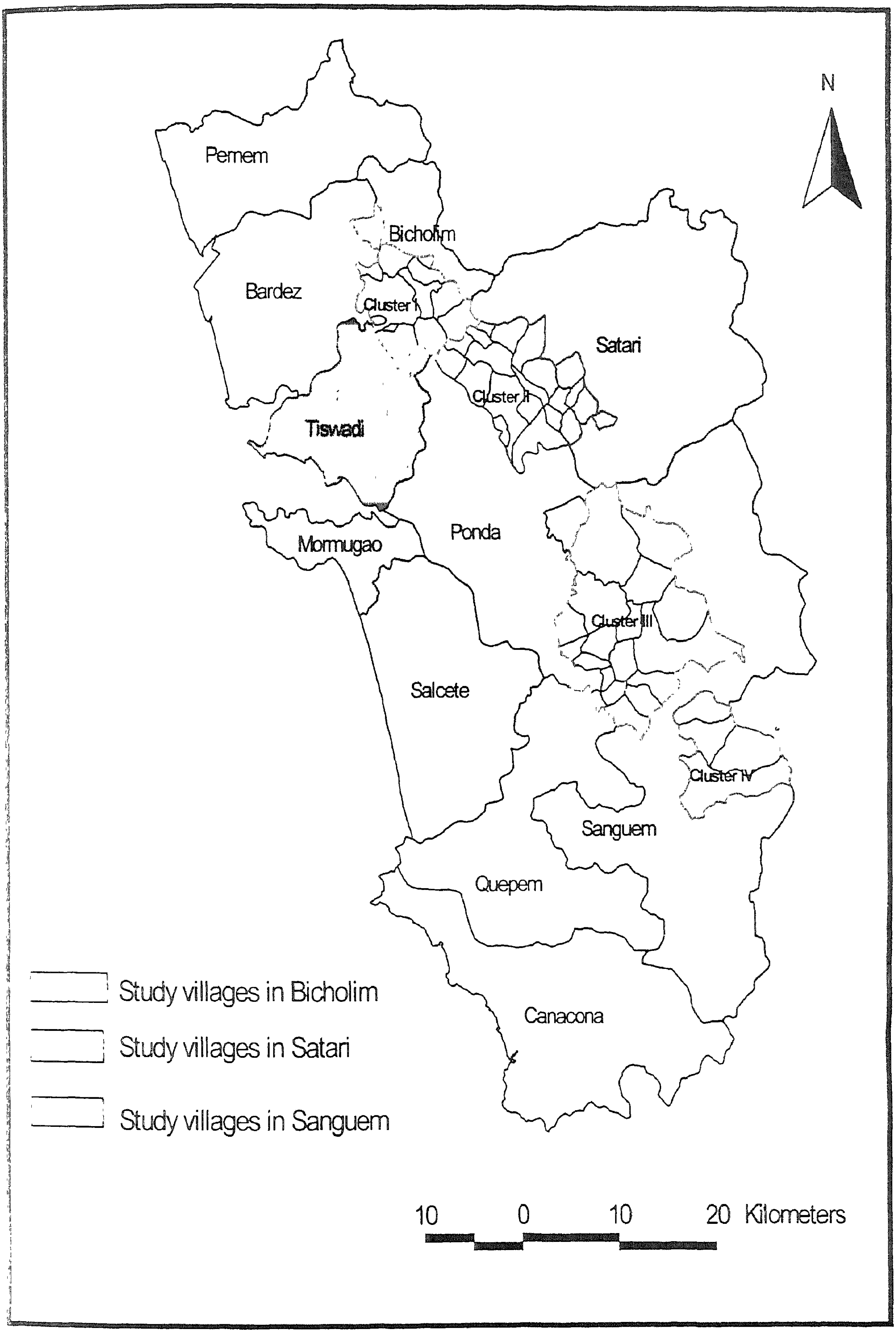


Fig 2.1 Goa : talukas and study area

Table 2.5. Area and population of clusters in relation to the mining talukas (in %)

Taluka	Share of area covered	Share of population covered
Bicholim	58	63
Satari	10	18
Sanguem	50	13
Clusters as % of talukas	39	45

Cluster I (Bicholim cluster)

This cluster is located in the northern part of Bicholim taluka and extends between Valvet river in the south and Chapora river in the north to the east of Mandovi river. This mining area is very close to habitation and agriculture areas.

Cluster II (Surla - Pale cluster)

The cluster is located partly in Bicholim taluka and partly in Satari taluka extending between Madei river in the south and Valvet river in the north to the east of Mandovi river. This is the most intensively mined cluster.

Cluster III (Codli cluster)

This cluster extends between Uguem river in the south and Ragoda river in the north to east of Khandepar river. The eastern tract of this cluster is mostly under forest.

Cluster IV (Tudou-Bati cluster)

This cluster extends to south of Uguem river and east of Zuari river comprising four villages In this cluster, which is mostly under forest area, the mining activity has gained momentum only in the last few years.

Iron ore reserves and ore characteristics

The iron ore formation of Goa belongs to the Dharwar Super Group which consists of four formations viz, *Barcem Formation, Sanvordem Formation, Bicholim Formation and Vageri Formation.* Of these Bicholim Formation is very important from commercial angle as it contains all the iron and manganese ore deposits of Goa. The Bicholim Formation overlies the Sanvordem formation confirmably and it includes quartz-chlorite-amphibole schist, ferrugineous pink phyllites, and bonded ferrugineous quartzitised. The formation extends in a general NW-SE direction. Broadly, the northern portion of the formation lying to the north of Usgao river is rich in iron-ore deposit, the southern portion of formation (south of Sanvordem) is rich in manganese ore deposits and the Central portion contains both iron and manganese ore of medium grade. The iron ore bodies are mainly haematite and occupy the crest and slop of hills. The ore body

generally dips towards east at 60 degree (maximum) and the average dip is 30 degree. Below the surface laterite cover (3 to 30 metres) hard lumpy ore occurs which is followed by friable and powdery ore

The first planned geological exploration study was undertaken by the GSI during the period 1962-68 Based on the data available, the reserves of iron ore were estimated to be 411 Mt in 1970 comprising of 81 Mt. of lumpy ore with + 60% Fe and the rest of fines with 62% Fe. The deposits of iron ore occur in a belt stretching over a length of about 95 km in N-S direction. The width of the belt varies from 3 5 to 7 km The northern block deposits are richer in terms of quantity and quality of the ore

A systematic measurement of iron ore deposits in North Goa in the early 1980s led to estimation of total *in situ* reserves of 1061 Mt. The ratio of lumpy to powdery ore is around 1:7, while the ratio of low grade to high grade ore is 2:3. Assuming certain recovery percentages, GSI has estimated that 625 Mt of iron ore would be recoverable. In South Goa, GSI has carried out geological investigations between 1966-72 and again from 1976-85 for assessment of iron ore and manganese ore The iron ore reserves of all grades were estimated at 680 Mt. Out of these reserves, the share of low grade ore is large. According to GSI, more detailed assessment of South Goa deposits are essential to establish and upgrade the reserves Based on the exploratory operations conducted and the deposit parameters compiled from the Goan mining companies, the iron ore reserves of all grades were assessed to exceed 2000 Mt. The deposit-wise details are given in Annexure 2 2 The mine wise and village wise insitu reserves and recoverable reserves have been collected from IBM and are given in Annexure 2.3.

Iron ore mining and production

The mining of iron ore started in Goa during the 1950s when the State was under Portuguese rule About 700 mining leases were granted in the territory but only a few were operating. By the end of 1950s, 2 Mt of ore production was achieved During the decade of the 1960s, some degree of mechanization was adopted in the mine and the production reached a level of 7 Mt by the end of 1960s However, the decade of 1970s witnessed a substantial growth in the ore production which increased to 13 Mt by the end of the decade The industry shifted its priority of mining lumpy ore to deep seated powdery ore Increased mechanization was necessary to mine the powdery ore at greater depths and also to meet the increasing demand. In the 1980s the production remained stagnant between 11 to 13 Mt per annum but in 1990s there has been a marginal increase to 14 to 15 Mt per annum The share of powdery ore production has increased from 85 to 90% Most of the mines now work below water table to depths of more than 50 metres Such mining involves high capacity water pumps and equipments like back-hoe excavators

In 1987 when the MMRD Act was made applicable to Goan mines, the number of leases sanctioned was 116 for a period of 10 years. Out of this in the last 3 years the number of operating leases in the study area ranged from 45 to 60. In 1996 the operating leases are reported

to be 42 It is also reported that in 1997, 93 leases have applied for renewal. These include operating leases as well as non-operating leases in the last few years. A list of leases granted, operating and applied for renewal in the four clusters are given in the Annexure 2.4 A summary of lease area, sanctioned and operating leases, and production cluster wise is given in Table 2 6

Table 2.6. Cluster wise mining details

Items	Cluster I	Cluster II	Cluster III	Cluster IV
Total lease area (Ha)	918.65	2265.31	3452.15	2084 33
Number of leases approved in 1987	16	36	52	12
No of operating leases in 1996	9	17	14	2
Iron ore production (Mt) in 1995	2 6 (17%)	5 9 (40%)	5 3 (36%)	1 0 (7%)
Overburden removal (M.cum)	7	15	13	3

The number of operating mines during the last 5 years varies from 25 to 30 The cluster wise and mine wise ore production from 1991 to 1995 is given in Table 2.7

Table 2.7. Cluster and mine wise ore production from 1991 to 1995

Company	Mine	Lease Area (ha)	Ore Production (Lakh tonne)					Village
			1991	1992	1993	1994	1995	
Cluster I								
Dempo	Bicholim	497 3	16 9	15 9	16 9	14 3	18 4	Mulgao, Lamgao, Bicholim
D Mangalji	Calsanichomato	47 3	0 3	1 4	0 6	1 4	-	Adwalpale
Bandodkar	Sirigao	96 0	3 9	3 6	3	3 2	4 4	Sirigao
Chowgule	Sirigao	172 1	3 5	2 4	2 5	2 5	2 8	Sirigao Maem
Sub Total		813 0	25	23 3	23	21 4	25 6	
Cluster II								
V M S	Cudnem	79 5	4 1	4 5	4 7	3 3	4 6	Cudnem
Timblo	Dignem	17 9	0 5	1 6	1 9	1 4	4 2	Cudnem
Sesa Goa	Cudnem	66 6	3 2	3 6	4 7	4 7	2 2	Pissurlem
V M S	Surla	286 6	13 3	15 2	11 9	11 7	11	Surla Velguem
Dempo	Surla	253 4	4 6	7 5	9 1	7 7	6 6	Surla, Sonshi Cormonem
D B Bandodkar	Matta and Dando	48.4	4 5	3 6	5 5	6 2	7 8	Velguem

Chowgule	Pale	152 6	13 5	11 2	9 2	7 2	3 3	Pale
Chowgule	Onda	74 6	-	-	-	0 2	0.3	Onda
Bandekar	Mollo	99 4	-	0 8	1 1	4 7	4 7	Pale
Bandekar	Madachem Bhat	64 8	-	0 3	0 3	0 8	-	Pale
D Mangalji	Duelem	99 5	7 2	7 1	8 9	9 3	10 3	Pissurlem
Salitho	Purmar E	94 6	2 3	1 9	-	-	0 5	Pale
V G Quenim	Sonshi	56 8	1	1	1 6	2 2	2	Sonshi
D S Gosalia	Khud Dorsa	62 3	-	2 3	3 1	3 8	1 4	Vaguriem
Sub-total		1457	54 2	60 6	62	63 2	58 9	
Cluster III								
Fomento	Sirigao	94	0 4	0 6	0 5	1 2	3 6	Sigao
SMI	Odamolla	359	7 4	7 9	5 8	9 7	11 7	Sangod
V S Dempo	Culnosoddo (Kirlapale)	82	5	3 5	4 9	4 9	5	Cormonem
Fomento	Cuddegal	91	4 6	4 7	4 4	3 2	4 4	Santona
N S Narvekar (Chowgule)	Kalay	268	3	3 2	5 4	6 2	5 1	Santona
Chowgule	Costi	128	1 6	1 1	0 2	-	-	Costi
Sesa Goa	Codli	423	25 3	25 6	29 1	39 1	20 6	Codli
Chowgule	Bimbol	146	-	-	0 1	5 2	2 5	Calem
Sub-total		1591	47 3	46 6	50 4	69 5	52 9	
Cluster IV								
R S Gharse	Tollem	100	2 3	2 6	4	5 6	7 7	Potrem and Tudou
Chowgule	Tudou	172	-	-	-	-	3	Tudou
S Kantilal	Bati	125	0 8	0 3	0 4	0 6	-	Bati
Sub-total		397	3 1	2 9	4 4	6 2	10 7	

Source GMOEA

Four large companies control 67% of the ore production and 68% of the export of the iron ore. The average production by these companies during the last three years is given in Table 2 8

Table 2.8. Company wise average production and export (1993-94 and 1995-96)

Company	Production, (Mt)	North Goa (%)	South Goa (%)	Export, (Mt)
Sesa Goa	3.8	30	70	3 7
Chowgule	2.1	40	60	1 8
Dempo	2 9	80	20	2.4
V M Salgaokar	1.4	100	-	2.2
Total	10.2			10 1

Source GMOEA, 1997

Mining operations

Mining operations are being carried out by forming systematic benches on the hill top and along hill slopes and the pits are laterally extended in stages in all directions with increasing depths In general, bench height and width are maintained at 7 m and 10 m respectively. The pit configurations are planned in such a way that the overall pits slopes remains at 30 degree or less with the horizontal. Sequence of mining operations involve systematic removal of lateritic overburden and mining lumpy ore zone followed by powdery ore zone Soft laterite is removed by ripping and dozing Drilling and blasting is practiced in hard laterite and lumpy ore zone where ever necessary To extract a tonne of powdery ore, on an average 2.5 cu m. of overburden material is required to be removed. This overburden material which consists of laterite, lateritic clay, manganiferous clay and phyllites, is dumped generally within the leasehold along the hill slopes, roadsides, and valleys. In some cases, overburden material is being transported to dumping sites outside the leasehold area. Normally overburden dumps are upto 30 m height but because of non-availability of land, mine operators have raised the height of dumps beyond 30 m

During mining, on the basis of working face samples and results as well as considering the borehole results, the quality of ore is controlled by stock-piling different grades of ore separately and mixing them at the required proportion, either at the beneficiation plant or at the loading point, to obtain the exportable grade of ore.

Ore beneficiation

The Goan iron ore mines are partially or fully mechanized. The demand for iron ore is in the form of sinter grade fines of 10 mm size with iron content of more than 62%. The ore being generally low grade (58-59% Fe) has to go through processing and beneficiation to meet the demand of foreign buyers. The mining companies have set up dry screening facilities at the mine and wet beneficiation plant at the mines or near loading points. There are about 18 dry screening plants with an installed capacity of 6000 t/h and 24 wet beneficiation plants with a capacity of 17 Mt per annum. The dry screening plants are a source of air pollution since large quantities of

dust are generated. In the wet beneficiations plants, the generation of large amount of tailings cause concern not only from point of view of utilization but also from the point of view of environment as well. Cluster-wise details of dry screening plants and wet beneficiation plants are given in Annexure 2.5 and 2.6

The normal process of ore beneficiation as applicable to most of the Goan ore is as follows The low grade ore with oversize +10 mm is crushed in stages in jaw/cone/roll crusher to size below 10 mm and screened or scrubbed wet. The undersize, in the form of a slurry, is fed into the classifier where the classifier sand is collected as part of the concentrate and the classifier overflow is treated in hydrocyclone. The underflow from the hydrocyclone constitutes the other part of the concentrate. The overflow from the hydrocyclone is the tailings/rejects of the process. The oversize from screen/scrubber can be treated as concentrate provided quality of the combined concentrate suits the overall grade On the other hand, it can be ground wet in a ball/rod mill and treated again in the hydrocyclone

Pelletization plant

There is 1 pelletization plant at Shiroda (9 Km. from Mudgaon) operated by Mandovi Pellets Limited (a subsidiary company of Chowgules). It has an installed capacity of 1.8 Mt per annum and the ore is obtained from Bellary area. Due to various reasons the plant is operating at much below its rated capacity. The export of pellets in the last two years has been 0 29 Mt (1995-1996) and 0.34 Mt (1996-1997).

Ore transportation by trucks

From the mines, ore is transported in 10 tonne tipper trucks to river-side loading points or to beneficiation plants. In the 1970s, mining companies began the practice of contracting out the transportation of ore to the beneficiation plants and loading points. The main reason was that the industry found it to be more efficient and economic to contract out the transport functions. Today, there is a large trucking industry for ore transportation and this has led to the setting up of a number of ancillary workshops to service and repair these trucks in the villages around the mining areas.

There are two types of truck owners within the industry those that are totally independent of mine owners and those trucks that are hypothecated to mining companies. Mining Companies such as Fomento, Timblo and Sesa Goa do not own any trucks but have a 100% dependency on hired trucks In North Goa, there is a far greater control over truck owners by mining companies. The following is the degree of ownership of trucks by mining companies Dempo 60%, Salgaoncar 100%, and Chowgule 30-40%. The practice of contracting out transportation has had the following consequences with mixed benefits to the region and industry. The practice has reduced the purchasing and maintenance cost of the trucks to the companies especially given the irregular demand for ore transport. It has, however, increased transaction costs for the companies of negotiating with transporters on rates and tonnages that are to be carried. This is less of a

problem for those mining companies especially in North Goa who have a system of lending finance for trucks. Contracting out transportation has created political and economic pressure groups within the mining region and competition among the groups for a stake in the industry It has now become very difficult for the mining industry to contemplate a change in the mode of transportation of ore to the loading points, as this would have serious political ramifications

Ore transportation by barges

Rivers Zuari, Mandovi and their tributaries are key factors in maintaining the economic viability of Goa's iron ore mines. Barging costs for transport of the ore to Mormugao harbour are lower than the cost of road or rail transport. The riverine system is navigable year round with the Cumbarjua canal providing sheltered passage from the harbour to the Zuari river during the monsoon season, June to September. However, during the monsoon there are no shipments of fine ore, because the heavy rainfall interferes with handling of fine ores by making them wet and sticky. In addition, it is learnt that the bulk carriers find it unsafe to carry fines as these forms a slurry with water and can shift the centre of gravity of the vessel. The combined navigable length of the rivers is about 65 km. There are 12 loading points on the river Mandovi and its tributaries and 4 loading points on the river Zuari. The details of loading points are given in Annexure 2 7 Barges may be loaded by conveyor systems or by rear-dump trucks dumping directly from barge-loading jetties. There are currently about 125 barges at the disposal of the Goan iron ore industry, the largest have capacities of 2000 DWT The average barge size is estimated at 1120 DWT capacity. The barges are mostly built in Goan shipyards The construction of barges with capacities of 2300 DWT is in progress At Mormugao harbour, the barges are unloaded mechanically at the plots allotted to the exporters, awaiting the arrival of their individual vessels Ship loading is also by mechanical means and, under perfect conditions, over 1,00,000 tonnes have been loaded into vessels in a single day. In addition, transhippers are also utilized to load into ships at mid sea.

Socio-economic scenario

The baseline socio-economic data for the villages/cluster has been compiled from 1991 census data and from the results of a socio-economic survey carried out in 23 villages in the mining areas Data for the talukas and the districts in which these clusters fall are also given for easy comparison. The number of villages/towns and their areas in each cluster and the comparative data for the taluka and district are given in Table 2 9.

Basic indicators

Table 2.9. Villages/towns in the area

	No of villages	No. of towns	Area (sq km)
Cluster I	13	1	65.8
Cluster II	21	1	122.52
Bicholim taluka	27	1	238 77
Satari taluka	72	1	495 13
North Goa district	220	6	1736 00
Cluster III	19	0	226 86
Cluster IV	4	0	77.27
Sanguem taluka	45	1	873.75
South Goa District	140	7	1966 00

Source Census of India (1991)

Population and literacy

Table 2.10 indicates a high density of population in clusters I and II and a low density of population in clusters III and IV. Comparison of the gender distribution of the population indicates that there are more males than females in the population of the clusters. The only exception is the case of Cluster III, where the females constitute 52% of the total population.

There is a high level of literacy amongst males and a moderate level of literacy amongst females Literacy levels amongst females in Cluster I and II are high as compared to Cluster III and IV as well as compared to the talukas. Only about a third of the females in Cluster IV are literate. In all the four clusters the females tend to be less educated than their male counterparts The socio-economic survey brings out more details relating to the educational levels attained by the population residing in these clusters.

Table 2.10. Population and literacy

	Population-1991			No of HHs	Pop-density/ sq Km	Literacy		
	Total	Percentage				Total	Percentage	
		Male	Female				Male	Female
Cluster I	23811	50 95	49 05	5715	361 87	15327	70 05	58 47
Cluster II	40467	51 79	48 21	7801	338	26670	74 23	56 96
Bicholim	84532	51 39	48 61	13396	354	57175	76 50	58 27
Satari	49530	50 58	49 42	8051	100	27530	65 78	45 16
North Goa district	664804	50 94	49 06	130363	383	457554	76 36	61 00
Cluster III	21617	47 14	52 86	4815	95.29	13111	76 57	46 46
Cluster IV	2437	50 06	49.94	546	31 54	1114	60.00	36 32
Sanguem	59355	51 07	48 93	11070	68	33813	65.91	47 74
South Goa District	504989	50 73	49 27	104234	257	322042	70.45	56 90

Source: Census of India (1991)

Worker distribution

Table 2.11 gives the worker distribution by clusters. Males dominate the distribution of workers in all clusters. Involvement of women in economic activity was found to be limited throughout the four clusters. The largest proportion of females amongst main workers is in cluster IV Except for this cluster, all other clusters have less than 35% of the women working towards earning an income. Majority of the women are found to stay at home, undertaking the daily chores of the house. The most common economic activity undertaken by women is that of an unskilled labourer either agricultural or otherwise. This is the situation prevalent in all of the four clusters as revealed in the socio-economic survey. Mining is an important economic activity in cluster II and III, where a fourth of the main workers are still engaged in mining activity. The socio-economic survey supports this and provides further information relating to the degree of direct and indirect dependence on mining activity in the clusters. Table 2.12 provides the sector-wise distribution of workers by clusters.

Table 2.11. Worker distribution by clusters and talukas

	Main Workers-1991			Mine workers as % of Main workers
	Total	% male	% female	
Cluster I	9423	70 72	29 28	10
Cluster II	14263	77 55	22 45	25
Bicholim	23223	77 85	22.15	17
Satari	15583	69 26	30 74	7
North Goa district	220625			
Cluster III	9645	67 68	32 32	24
Cluster IV	1170	59 15	40 85	17
Sanguem	20824	68 65	31 35	19
South Goa District	162934			

Source Census of India (1991)

Table 2.12. Sector-wise distribution of workers by clusters, 1991 (%)

Cluster	Agriculture	Forest & fisheries	Mining & quarrying	Secondary	Tertiary
I	36	3	10	19	32
II	22	3	25	20	30
III	30	7	24	13	26
IV	55	11	17	4	13

Source Census of India (1991)

It is evident that agriculture is still an important economic activity in all four clusters, but most so in Cluster IV Clusters I and II are well diversified into non-mine activity and this is especially true for Cluster I Forestry is of some importance in Cluster IV.

Health and education facilities

The census data given in Table 2.13 reveals that the clusters are well served by educational and health infrastructure. However, visits to certain villages indicated that these schools are quite distant from the villages, especially middle and high schools. As to health, while the infrastructure is available, there is often a shortage of doctors and a lack of easy access to medical care when needed.

Table 2.13. Education and health facilities

	Education					Health				
	Primary	Middle	High school	Higher Sec	Coll-ege	Primary Health Centres	Family Welfare Centres	M C W	TB Ctr	Hospitals
Cluster 1	42	12	7	NA	5	5	5	NA	NA	NA
Cluster 2	82	11	6	NA	3	5	5	1	1	2
Bicholim	105	37	23	6	2	1	22	6	NA	NA
Satari	118	34	22	2	NA	1	20	2	NA	NA
North Goa district	746	277	205	46	13	12	163	18		73
Cluster 3	65	7	7	NA	2	7	7	1	1	NA
Cluster 4	7	1	1	NA	NA	2	2	NA	NA	NA
Sanguem	128	26	21	3	NA	1	20	NA	NA	NA
South Goa District	1271	458	354	75	21	21	268	25	N A	48

N A Information not available
Source Census of India (1991)

Results of the socio-economic survey

To have a closer look at the interconnection between mining and the local community, a socio economic survey of 23 mining villages in the study area was undertaken in February 1997 This survey has provided a window to the lives of persons residing in the clusters. This section concentrates on the information that have emerged about the current socio-economic conditions prevailing in each of the clusters.

Length of residency of households

A households length of residency in a particular area is an important socio-economic indicator as it serves a twofold purpose - firstly, longer the term of residence of a household, greater is the households' ability to perceive the changes in their lifestyles and environment Secondly, length of residency provides information about the extent of migration into the area.

The survey results show that majority (over 60%) of the households in the four clusters have been residing in the area for more than 20 years. Although, there has been limited recent in-migration to the clusters 10%, 12% and 2% for Clusters I, II, III respectively, Cluster IV is the

only cluster where the study indicates that no in-migration has taken place over the past ten years Table 2.14 outlines the length of residency of the households for each of the clusters.

Table 2.14. Length of residence - cluster wise (% households)

No of years	Cluster I	Cluster II	Cluster III	Cluster IV
Less than 10 years	10.5	12.4	2 4	0
10-20 years	4 7	7 9	3 4	30 2
More than 20 years	79 5	78 4	92 3	65 1
Non responses	5 3	1 2	1 9	4 6

Migration of people from one area to another is predominantly driven by the availability of employment opportunities. Table 2.15 illustrates this phenomena very clearly in the cases of Cluster I, II and III with 27%, 66%, 75% of the families having cited employment as the primary reason for migration Cluster IV has reasons other than employment been identified for migration. This is because a part of this cluster covers an area where many of those displaced by the Selaulim dam have been resettled.

Table 2.15. Main reasons for migration (% households)

Reasons	Cluster I	Cluster II	Cluster III	Cluster IV
Employment	27 6	66 0	75	7 7
Education	0	1 0	0	0
Any other (land, resettled, etc)	27 6	17 0	16 7	76 9
Non responses	44 8	16 0	8 3	15 4

It is interesting to note that in the past decade, despite new mines being opened in cluster IV, no new immigration has occurred during this period.

Economic dependence of households on mining

Mining in Goa supports a sizeable population In clusters II and III, 44.8% and 37.2% of the households are involved with mining either directly by employment with the mine companies or indirectly through working as truck owners/drivers, garage workers, cleaners, etc. Economic dependence on the mines in Clusters I and IV is however considerably lower as shown in Table 2.16. At present, mining activity is still very active in clusters II and III (see Table 2.16) as compared to clusters I and IV. Mines in cluster I are either closed or nearing closure. Besides, the presence of various other economic opportunities in the area reduces the dependence of locals on the mines of the region. In case of cluster IV, mining activity is still at the inception stage so few local people are involved with the activity. Thus the findings point to a direct relationship between the stage of mining activity in a cluster and the economic dependence of the people on mining.

Table 2.16. Cluster wise dependence on mines (% households)

Households	Cluster I	Cluster II	Cluster III	Cluster IV	Mining belt %
No Dependence	77 9	55 2	62 8	79.1	62 6
*Dependence**	21 1	44 8	37 2	20.9	37 2
of which					
*1 Direct Dependence***	*72 5*	*65 5*	*62 3*	*66 7*	*0*
*2 Indirect Dependence****	*27 5*	*34 5*	*37 7*	*33 3*	*0*
Non responses	1 1	0	0	0	2

* Includes all households that have at least one person involved with mining activity directly or indirectly.

** Includes only households that have at least one person working directly in the mines as a technician, supervisor, blaster, labourer, etc.

*** Includes only households that have at least one person owing trucks used for mining, driving mine trucks, garage workers etc

As per the survey results, for the mining belt as a whole, approximately 37% of the total households are economically dependent on the mining sector.

The table 2.16 further differentiates between direct and indirect dependence of households on the mining activities Economic dependence through direct employment in all the four clusters is above 60%. Economic activities related indirectly to mining are also important sources of employment for the households forming about 30% of the total employment in the mining sector.

Dependence on agriculture

Apart from mining, agriculture is an important economic activity in the region. The results of the survey indicate that approximately 30% of the households of clusters I, II, and III undertake farming (Table 2.17). It is only in the case of cluster IV where agriculture is the predominant economic activity Over half of the households in this cluster undertake farming. Such a scenario can be attributed to increased growth of secondary and tertiary sectors in the first three clusters in comparison to the growth of these sectors in cluster IV

Table 2.17. Percentage of households undertaking farming

	Cluster I	Cluster II	Cluster III	Cluster IV	% for the mining belt
Households undertaking farming	26 8	25 1	27 5	53.5	35

Dependence on irrigation for agriculture

The socio-economic survey revealed that use of different types of irrigation sources for agriculture is a common practice in the mining belt. Majority of the households that undertake farming were found to irrigate their fields. Dependence on irrigation varies from as high as 96% in Cluster I to 56% for Cluster IV (Table 2.18).

Among the various types of irrigation that is used in the region, the most common sources of irrigation are ponds and tanks. Only in cluster III are canals the main source of irrigation. Besides ponds and tanks, mine water is used for irrigation purposes by about 20% of the households mainly in clusters I and II. This is probably due to the fact that in these clusters, mine companies have been making mine water available to the local farmers on a regular basis.

Table 2.18. Irrigation used by households cluster-wise (% households)

Irrigation source	Cluster I	Cluster II	Cluster III	Cluster IV	% use in mining belt
Tubewell	2	2.6	11.4	0	4
Canal	2	1.3	48.6	0	10.9
Well	6.1	7.7	5.7	7.7	6.9
Mine water	26.5	20.5	0	0	16.6
Ponds & tanks	42.9	56.4	17.1	76.9	46.3
River	2	6.4	8.6	7.7	5.7
Mine water & ponds	8.2	2.6	2.9	0	4
Canals & ponds	0	1.3	0	0	0.6
Ponds & rivers	0	0	2.9	0	0.6
Unknown	10.2	12.8	2.9	7.7	4.5
Percentage of farming households that irrigate	96.1	63.4	61.4	56.5	

Literacy in the clusters

On comparing the literacy levels among the four clusters, it is observed that the population of cluster I is more literate, while, high illiteracy levels are seen in clusters III and IV. Furthermore, higher education levels are lowest for cluster IV with only a few males attending college. It is in cluster I that there is a higher percentage of graduates and post graduates. Table 2.19 illustrates the literacy rates for each of the clusters

Table 2.19. Literacy levels distributed gender wise (%)

	Cluster I		Cluster II		Cluster III		Cluster IV	
	Males	Females	Males	Females	Males	Females	Males	Females
Illiterate	8.6	24.1	14.5	31.1	23	40.8	21.7	40.9
Primary	18.0	14	19.2	19.4	20.4	13.5	27	20.9
Middle	25.1	23.9	27.1	24.2	24.7	22.3	25.2	23.5
High	26.5	20.4	22.4	15.9	23	15	16.5	10.4
Higher Secondary	9.4	10.3	8.7	4.7	5	5.6	6.1	4.3
Graduation	7.7	5.9	6.1	4	3.6	2.6	3.5	0
Post graduation	2.2	7	6	3	3	0	0	0
Diploma	2.6	.7	1.3	3	0	.2	0	0
Any others	0	0	0	1	0	0	0	0

Status of women in the community

In the study, a certain degree of emphasis has been placed on the females of the population. Such a stance has been adopted because females are often discriminated against, are economically backward and are the ones who experience hardships due to resource scarcity. Therefore, the study tries to portray the status of the women in each of the clusters.

Gender literacy

Comparing literacy rates between the genders provides insights into the extent of social development of the women. The survey results indicate that the percentage of illiterate females is double that of the males. This male-female differential in the literacy rates is reduced for primary and middle school as approximately an equal proportion of the genders are educated to this level. Furthermore, there is an overall decline in the percentage of persons educated beyond the high school level. This decline is sharper in case of females of the population and most prominent in clusters II and III. The sharp decline in percentage of females attending higher education can be explained by the fact that the large numbers of dropouts after high school mostly constitute of females.

The reason for dropouts are several from marriage of the girl, to the parents inability to afford the education of the girl child. Women in cluster I are found to achieve higher education levels than in any of the other clusters, an indication of the populations realization about the importance of higher education for women

Amenities available in the mining belt

Access to water, electricity, fuel, sanitation are indicators of the extent of developmental infrastructure that is available to the population.

Main sources of drinking water

Almost all the households in the clusters use multiple sources of water throughout the year. Wells are the predominant source of water for households in clusters I, II and III with 74%, 52% and 50% dependence respectively. Piped water is the primary source of water for cluster IV and a secondary source for the other three clusters. A significant number of households are also dependent on local rivers and streams for meeting their potable water needs. This is more significant to clusters III and IV which demonstrate greater dependence on these sources. Tankers are an important source of water for households in cluster II Many households in this cluster experience severe water shortages during the summer months. Water needs of the population then have to be met through PWD or mine tankers bringing water to the people on a daily basis. Table 2.20 provides detailed information about the different sources of water for the clusters.

Table 2.20. Source of drinking water for clusters (% households)

Source	Cluster I	Cluster II	Cluster III	Cluster IV
Well	74.2	52.6	50.2	1.4
Tube well	10.5	22.4	7.3	0
Piped water	29.5	32.6	30.4	53.5
Stream/river	4.2	7.9	34.3	46.5
Tankers	0.5	14.1	5.3	2.3

Note: Houses use multiple sources of water, hence the table does not tally to 100

The high dependence on wells in three clusters is because the present piped water network is not extensive. In most instances the water pipeline supplies water through community taps located at regular intervals but leaves large areas of the village far away from these taps. Moreover, the piped water supply is highly irregular. In most villages the water pipelines are newly constructed and the wells have been the traditional source of water for the people. Some of the wells are either government constructed or private. It is often the more affluent families of the village that have constructed their own well which is close to the house providing water most of the year to a small group of families.

The survey reveals that the clusters dependence on the various water sources across seasons (June-September, October-February, March-May) varies only marginally. In the summer months, few households shift from the use of private wells to piped water or nearby rivers This analysis however blurs the fact that some villages within the clusters do face severe water shortages and have a high dependence on tankers.

Another aspect related to water is the distance that households must travel to collect water The survey revealed that majority (47%) of the households have access to a water source within 100 m of their house (Table 2 21). Cluster I has the highest percentage of households with access to private water source In contrast, Cluster III has only 6% of its households having access to private water sources and in fact has the highest percentage of households (21%) traveling more than 500 m to collect water The probable explanation for the observed trend lies in the fact that cluster I consists of urban/semi urban areas which are served by a water pipeline through private connections while in cluster III, the existing pipeline covers a restricted area and water is essentially supplied through public taps rather then private taps. Cluster II and IV also have a large percentage of households traveling more than 500 m to collect water, an indication of limited water sources available to the people.

Table 2.21. Distance traveled to a water source (% households)

	Cluster I	Cluster II	Cluster III	Cluster IV	For mining belt
In house	41 1	32 6	6 3	11.6	22 1
100 m	69 7	50 5	68 4	58.1	47 2
100-200 m	4 3	15 3	20 9	20.9	11 7
200-500 m	2 7	10 1	5 3	4.7	5 9
> 500 m	3 8	18 5	21 4	20.9	13 1

Note The table does not add to 100 due to households using multiple sources of water.

Electrification of households

Goa as a state is considerably well electrified. The socio-economic survey results show that the extent of electrification in all the four clusters is considerably high, ranging from above 90% in clusters I and II to 76% in cluster IV. However, cluster IV once again is comparatively less developed than the other clusters, having a comparatively larger number of households (20%) that do not have access to electricity. Table 2.22 shows the extent of electrification in the clusters.

Table 2.22. Extent of electrification in the clusters (% households)

Electrification	Cluster I	Cluster II	Cluster III	Cluster IV
Yes	94 2	92 7	86 5	76 7
No	4 2	7 3	13 5	20 9
No responses	1 6	0	0	2 3

Availability of sanitation facility

Majority of the households in the four clusters do not have access to basic sanitation facilities. Private toilets facilities are available only to about 34%, 26%, 13% and 7% of the households in the each of the clusters (Table 2 23). Presence of private toilets in households is a crude indicator of affluence of a household The trend exhibited by the private toilet ownership among the clusters corresponds to the extent of economic development in the cluster Dependence on public toilets is maximum in Cluster IV, with about 25% of the households using these facilities. In the remaining three clusters, use of public toilets is below 5%

Table 2.23. Cluster wise household availability of sanitation facilities (% households)

	Cluster I	Cluster II	Cluster III	Cluster IV
No Toilet	55 8	67 4	76 8	65 1
Private toilet	34 2	26 1	13 5	7
Public toilet	0 5	4 1	4 8	25 6
No responses	8 5	2 4	5 0	2 3

Types of houses

The survey indicates that among the villages of the 4 clusters, cluster IV has the highest ownership of pucca houses (Table 2.24). However the predominant house type in the mining belt

is semi-pucca houses, approximately 60% of all houses are of this type. The highest percentage of kutch houses are located in cluster II (15.7%).

Table 2.24. Types of houses (% households)

	Cluster I	Cluster II	Cluster III	Cluster IV	For mining belt
Pucca	28.1	23 2	29 1	48 8	26 7
Semi-pucca	64.3	61 1	57 3	37 2	59 9
Kutcha	7 6	15 7	13.6	14	13 5

Main source of fuel for the households

The type of fuel used for cooking by a household, is also dependent on the economic status of that household. A household shifts to modern cooking fuels like gas and kerosene from traditional sources like firewood with improvement in living standards Among the four clusters, cluster I has majority of households (39%) that use gas for cooking. An indicator of greater economic means available to households in this cluster compared to those of the other clusters Table 2.25 provides the scenario related to fuel use in the clusters.

Table 2.25. Types of fuel used in the clusters (% households)

	Cluster I	Cluster II	Cluster III	Cluster IV
Gas	39	23 4	5 3	0
Kerosene	2 6	5 1	0 5	0
Firewood	30 5	57 8	80 7	100
Twigs	0	0	0 5	0
Dung	0.5	0	0	0
Gas & firewood	19	8 4	3 9	0
Kerosene & firewood	3.7	6 1	5 8	0
Any other	0	0	0 5	0
No responses	4.7		2 9	0

Firewood is the primary fuel for clusters II, III and IV with latter having 100% dependence on this source. Some households from clusters I, II and III are users of a combination of fuel sources basically gas or kerosene along with firewood. The high reliance on firewood, to an extent, also depends upon the availability of firewood in the area. Cluster IV is relatively sparsely populated with sufficient forest in the area therefore, firewood is easily available. This is not the case for cluster I which is well inhabited with little open spaces, thus households have to use alternative fuel source (like gas) to meet their needs. Growth of population in an area leads to a decline in the tree cover, compelling households to shift to alternative fuel sources.

The survey results indicate that there is a scarcity of fuelwood in the mining belt. Approximately 68% (Table 2.26) of the surveyed households that do collect fuelwood are forced to walk over a kilometre to collect the fuelwood necessary for meeting their requirements. Among the clusters, cluster I has the highest percentage of households forced to cover over a kilometre, this is followed by cluster IV households. The interesting point to note is that, most households of cluster I have moved to modern fuels while cluster IV households have continued to be dependent on fuelwood The possible reason for this might be the easy access to alternative fuels for households of cluster I in comparison to those of cluster IV. Therefore, in spite of the great distance the cluster IV households have to travel to collect wood, the lack of alternative fuels has forced them to continue being dependent on fuelwood. A large percentage of the cluster II and cluster III households also have to travel over a kilometre to collect fuelwood.

Table 2.26. Distance traveled to collect fuel wood (% households)

	Cluster I	Cluster II	Cluster III	Cluster IV	For mining belt
Less then 100 m	12.2	3.7	8	-	5.5
100-500 m	4.1	7.3	28.4	16.7	14.3
500-1km	-	15.8	11.1	2.4	11.8
More than 1km	83.7	73.3	52.5	80.9	68.3

Opinions of the households about mining activities in their area

During the socio-economic survey, the opinion of the population about mining activities in their area was collected and a statistical analysis was done on the data. The results are as follows:

Amenities provided by the mining companies

Throughout the mining belt, over 65% of the households are of the view that mine companies operating in their areas have not provided any amenities (i.e. water, sanitation, health services, etc.) for the community living in and around the mines (Table 2.27). This feeling is most prevalent in cluster IV where 90% households claim "no benefits". On the other hand, 43% of the cluster II households state that mine companies in their area has provided the surrounding community with services from which the locals have benefitted.

Table 2.27. Opinion about amenities provided by the mine companies (% households)

	Cluster I	Cluster II	Cluster III	Cluster IV	For mining belt
Yes, have provided	18.4	43.8	18.4	9.3	31.4
No, have not provided	73.2	54.8	78.7	90.7	65.5
Don't know	2.1	0	0	0	0.5
Unknown	6.3	1.4	2.9	0	2.5

Benefits from mining to the village

In the mining belt as a whole, only 32% of the households questioned felt that their villages had benefitted from the mining in the area (Table 2.28). It is only in cluster III that a greater number of households (40%) were of the opinion that their village had gained from mining Households of cluster I and II perceive mining activity as not really being beneficial to the village. Cluster IV where mining is still at the initial stages of growth, households were unsure to the extent of benefits from the mining activity.

Table 2.28. Opinion about whether the village has benefitted from mining (% households)

	Cluster I	Cluster II	Cluster III	Cluster IV	For mining belt
Yes	21 6	33 8	40.6	20 9	32 2
No	63 2	52 5	35 3	39 5	50 4
Don't know	11 6	13	22.7	39 5	16 1
Unknown	3 7	0 6	1 4	0	1 3

Issues of concern to the people

Apart from determining the socio-economic status of the people residing in the mining belt, the survey also ascertained the issues of concern to the people. These issues provide valuable insights into the prevailing conditions in the clusters related to availability of resources, basic services, and infrastructure. Table 2.29 provides details of these issues

The people have identified numerous issues that are of concern to them but among them lack of water (essentially potable water) is the most pressing problem for the households of the mining belt In clusters II, III and IV 42%, 56% and 58% of the total households have highlighted the issue of inadequate availability of water. Although households have access to multiple sources of water, scarcity of water is specially acute during the dry summer months It is between the months of March and May when the local sources of water i.e. wells, and streams turn dry and piped water supply becomes more irregular. Households then resort to using any available water source In many instances unclean or highly turbid water is the only source of water for the households

Among the clusters over 50% of the households in cluster III and IV have raised lack of water as an issue. It is interesting to note that it is these 2 clusters that have the highest dependence on local rivers and streams (refer to Table 2.20).

Table 2.29. Identified issues of concern (% households)

Issues	Cluster I	Cluster II	Cluster III	Cluster IV	For mining belt
Lack of water	24.2	42	56.5	58.1	42.3
Dust pollution	14.7	30.4	15.6	7	22.8
Unemployment	18.9	21.4	17.9	53.5	21.6
Lack of transport	10	14.1	38.7	16.3	18.8
Destruction of land	3.2	29.1	8.2	-	17.8
Health problems	1.6	12.8	20.8	7	12
Lack of sanitation	15.3	6.7	17.9	-	10.6
Water pollution	3.2	8.6	8.7	4.7	7.3
Bad roads	6.8	6.7	5.8	-	6.1
Distances of services	-	4.1	15.9	2.3	5.8
Noise pollution	2.6	6.5	3.4	7	5.1
Blasting	3.2	1	1.5	-	1.5
Scarcity of firewood	-	1.4		-	0.8
Shortage of land	2.1	0.4		-	0.6
Others	13.1	11.8	5.8	11.6	10.6
No problems	26.8	9.2	2.9	2.3	11.1

Note The figures do not add up to 100 because multiple issues were identified by the households

Apart from the issue of scarcity of water which is common to all 4 clusters, households have identified distinct issues pertaining to their surroundings which impact on their well being. The issue of dust pollution is cited as a problem by over 30% of households of cluster II in contrast to less than 15% in cluster I and III and only 7% in cluster IV. Furthermore, cluster II also has the highest percentage of households raising the issue of destruction of land. The rationale for cluster II's complaints about dust pollution and destruction of land lies in the fact that at the present time this area is very intensively mined, far more than the other clusters so people living in the mining villages experience the intensity of the problems.

Unemployment is another issue of concern in the mining belt, although the degree of concern varies among the clusters. Cluster IV has the highest percentage of households identifying unemployment as a problem (53%). Lack of development in the form of industrial estates, factories etc. has meant that there are limited employment opportunities available to the

people of the region. Agriculture is the main economic activity here but there is a general need felt by the people to move away from farming which is not seen to be very remunerative

Inadequacies of existing services like health, transport and sanitation is also highlighted by the people. Cluster III has the highest percentage of people viewing these as a concern for them.

Also important to note is the fact that about 11% of the households of the mining belt felt that there were no problems in their region. Among the clusters it is essentially the households of cluster I that expressed this view

Construction of the societal index

In this chapter the socio-economic discussion so far has concentrated on cluster level comparisons. However, this approach conceals the differences existing between villages within a cluster. To facilitate comparisons among the surveyed villages, the study has developed a societal index for each of the villages. The societal index constructed for the villages is a composite of 3 indicators: "activity", "organization" and "resilience". These indicators were chosen to reflect the health of the system: the more active a village, the more stable and viable its organization and the greater its resilience, and therefore greater its ability to cope with current and potential future stresses. To arrive at these three indicators the following parameters were used:

For the activity indicator

Income per capita for each of the villages was calculated on the basis of worker participation in the various economic categories

For the organization indicator

Factors that are considered important for the viability of the village in a mining settlement context were chosen. These are taken to be the level of literacy among males and females of the population, the sex ratio, the alternative non-mine opportunities available in the villages and the extent of overall dependency among the population (non-working population in comparison to working population).

For the resilience indicator

This is an indicator of the extent to which a population is able to cope with stress and challenges. The parameters studied here are (i) percentage of population educated beyond middle school level as this increases their range of competencies, (ii) the standard of living as measured by the

availability of the following amenities: distance that a households must travel to collect water and sources of water, access to sanitation facility and modern fuels for cooking, extent of people living in permanent dwellings and (iii) the extent to which the economic resource base has not been affected by mining activity. In this case, the degree of silting of croplands was taken to be an indication of a reduction in potential for alternative employment in the event of a mine closure. The obverse, i.e., villages where cropland is not affected are considered more able to cope with eventual closure and /or other stresses.

In order to generate the Societal Index, the following was done:

- Percentages calculations were performed using the socio-economic survey and the Census data of 1991, to arrive at the indicator data,
- Indicator data was summed across to arrive at an indicator value; Each parameter used to arrive at the indicators has assigned equal weights.
- The use of maximum and minimum values has been adopted as done in the Human Development Report to arrive at a Human Development Index. Minimum and maximum values for all three indicators - activity, organization and resilience- were obtained from these calculations and were assigned values ranging from 0 to 10 for each village, i.e , the village with the lowest value being assigned 0 and that with the highest value assigned 10. The only exception was for calculating the water source used by the households of a village. In this case river and tankers were judged the worst water source assigned values of -2 and -1 respectively. The other water sources wells, tubewells and piped water were assigned values 1, 2 and 3 (See Table 2 30)
- The scores for the three indicators for each village were then summed up to arrive at the composite index. The lower the value of the index the more stressed the village and less able to cope with problems; the higher the value of the index the more healthy the village and able to cope with potential problems.

Using the societal index, it was possible to rank the villages studied The results of the scoring indicates that different villages rank differently for each of the indicators (Table 2 30).

The scores for the activity indicator, represented by the per capita income in a village, is lowest among the surveyed villages of Surla, Velguem, Ponocem in cluster II and Sirigao in cluster I.

Pissurlem of cluster II and Cornonem of cluster III score poorly on the organization indicator. The responsible factors for the low scores are high prevalence of illiteracy among females (in Pissurlem) and males (in Cornonem) as well as the existence of a highly unequal gender distribution among the population. Pissurlem also has a significant percentage of the population as dependents along with high economic dependence on the local mining activity in

the village. All these factors affect Pissurlem's overall performance under the organization indicator.

With respect to the resilience indicator, Darbandora's score is the lowest. The village scores poorly on almost all parameters of resilience, affecting the well being of the people Pissurlem village too has low resilience.

The summation of the scores of all the indicators (activity, organization and resilience) for each of the villages provides ranking of the villages. As per the societal index the worst affected villages are Tudou, Pissurlem, Darbandora, Patiem, Sangod and Codli. This indicates that the villages of Cluster II and III are the socially worst off. It is again the re-enforcement of the opinion that presence of extensive mining in these clusters has a negative impact on the quality of the local environment which, adversely effects the well being of the people living in the areas.

Summary

Mining is still an important economic activity in Goa, contributing 7.7% of NSDP; its importance in the villages and talukas is high, both in terms of the economic activity it generates and the employments of locals; the dependency on the older mines of cluster I has gone down considerably and there is significant diversification of workers out of mine activity The dependence in the other three clusters, however, is still high, although diversification from mine to non-mine activity is significant Villages in which mining activity has been going on point to a number of problems perceived to have been generated by mining activity and/or due to lack of attention by state and local governments. These relate to water shortages, dust related diseases, lack of transport and health facilities, unemployment and impacts on agricultural land

Table 2.30. Village-wise societal index parameters

Name of village	Regional income per capita	Organization indicator					Resilience indicator							Composite Societal Index
		% of total females literate	% of total Males literate	Sex ratio	% workforce in non-mine activities	Working population as a % of total	% educated beyond middle school	% Households travelling 100 m to collect water	Source of water	Access to sanitation facility	Do not use fuelwood	Households owning pucca houses	Households not affected by silting	
Cluster I														
Singao	1	5	8	3	2	0	8	10	18	1	7	1	10	74
Lamgao	NA	9	8	NA	5	5	9	8	19	2	9	2	10	86
Mulgao	1	8	8	3	6	4	7	6	15	2	7	2	10	79
Bordem	NA	9	7	NA	8	7	10	10	16	7	10	4	10	98
Cluster II														
Arvalem	4	7	5	4	7	10	8	9	23	5	6	4	10	102
Cudnem	4	6	5	1	4	6	7	3	21	1	5	4	1	68
Velguem	1	9	7	2	0	6	6	10	20	4	7	1	0	73
Pale	2	5	7	1	4	7	7	0	18	1	4	1	3	60
Ponocem	1	7	6	1	1	8	5	10	14	10	6	10	10	89
Onda	5	3	4	2	4	6	6	10	26	4	5	9	7	91
Pissurlem	7	0	5	1	1	1	5	2	11	1	3	0	2	39
Sonshi	6	7	7	3	1	1	5	5	14	4	6	1	3	63
Vagurnem	10	6	3	0	8	10	3	2	3	2	2	2	10	55
Surla	0	8	6	3	3	6	8	5	13	3	5	0	3	63
Cluster III														
Darbandora	3	4	3	2	3	5	6	3	2	1	0	4	6	42
Sangod	4	5	1	2	6	7	6	6	22	6	1	0	10	52
Cormonem	3	3	0	0	3	3	10	9	29	0	2	0	10	72
Codli	6	6	5	3	2	5	7	7	16	2	3	3	2	52
Santona	7	5	4	0	4	7	5	4	13	2	3	0	10	64

Sigao	5	3	0	2	6	9	7	3	6	2	2	6	10	61
Cluster IV														
Bhati	6	4	4	4	6	9	6	5	13	4	0	5	10	76
Todou	4	8	10	2	1	7	0	4	-14	0	0	0	10	28
Patiem	3	4	0	10	10	7	1	5	-4	0	0	0	10	46

N.A.

Annexure 2.1. Area and population, of villages in the study area

Sl.No	VILLAGE/TOWN	Area (km2)	Population 1991	Density pop/km2
	CLUSTER I			
1	ADWALPALE	6.4	1453	228
2	SIRIGAO	2.9	1721	600
3	MULGAO	7.6	2797	369
4	SARVONA	7 9	1405	179
5	MAEM	21.0	7308	347
6	CARAPUR	8.6	4749	550
7	PILIGAO	8.2	2632	322
8	ATURLI	0.7	504	741
9	VAINGUINIM	0.7	724	1065
10	ONA	1.9	518	273
11	LAMGAO			
12	BICHOLIM			
13	NAROA	8.0	1978	247
	TOTAL	73.8	25789	349
	CLUSTER II			
14	SANQUELIM	0.5	2427	5393
15	VIRDI	3.1	1201	387
16	NAVELIM	10.9	2315	213
17	MAULINGUEM SOUTH	4 0	2870	714
18	COTOMBI	3 7	953	260
19	CUDNEM	9.9	3012	304
20	SURLA	16.9	5096	301
21	VELGUEM	3.2	2536	783
22	PALE	13 5	6457	477
23	ARVALEM	7.2	2590	362
24	ONDA	7 9	2938	371
25	PISSURLEM	8.3	2028	243
26	SONSHI (SONUS VONVOLIEM)	4.7	453	96
27	VAGURIEM	3 1	279	90
28	CODIEM	2 5	74	30
29	ADVOI	5 8	624	108
30	PONOCEM	3 0	439	147
31	VANTEM	5.9	1231	208
32	BIRONDEM	2 8	348	125
33	CUMARCONDA	5.6	394	71
34	AMONE	7.3	2826	385
	TOTAL	129.9	41091	316
	CLUSTER III			
35	DARBANDORA	44.6	1023	23
36	SANGOD	16.0	855	53
37	CORMONEM	6.2	642	104

38	CODLI	24.0	3837	160
39	CAMARCONDA	8.0	822	103
40	BANDOLI	8.0	1699	213
41	SANTONA	8.9	912	102
42	SANCORDEM	21.2	1243	59
43	SIGAO	30.1	912	30
44	CALEM	35.8	2577	72
45	DUDAL	7.7	516	67
46	COSTI	6.9	905	132
47	CORANGINIM	4.2	54	13
48	COMPROI	120.0	653	5
49	MUGULI	7.6	467	61
50	MOSSAL	3.0	69	23
51	RUMBREM	3.8	409	107
52	SAVORDEM	5.1	4022	787
53	ANTORIEM	2.3	0	0
	TOTAL	363.3	21617	60
	CLUSTER IV			
54	PATIEM	12.1	245	20
55	TUDOU	13.0	295	23
56	POTREM	22.3	130	6
57	BATI	30.0	1767	59
	TOTAL	77.3	2437	32
	GRAND TOTAL	644.2	90934	141
	MINING TALUKAS			
	BICHOLIM	238.8	84532	
	SATARI	495.1	49530	
	SANGUEM	873.8	59355	
	TOTAL	1607.7	193417	
	STUDY AREA AS % OF MINING TALUKAS	40.1	47	

Annexure 2.2. Iron ore resource base in Goa

Iron ore deposit/occurrence	Ore type	Ore reserve category	Reserve *in situ* (m.t.)	Grade (Fe%)
Adwalpale	Lumpy Ores 18% Sore fines 82% Haematite ore	CI	25	54-64
Bicholim-Sirigao	Lumpy ores 26% Ore fines 74% Haematitie ore	B + C	385	53-62
Sanquelim-Sonshi, Sanquelim Usgaon	Lumpy ores 10% Ore fines 90% Haematitie ore	B + C	579	4-63
Other deposits (Pirna, Vazri-Nanora, Nagjohr; Borde-Sarvona, Dhabadhaba, Surla-pate plateau, Sanquelim carapur	Lumpy ores 16% Ore fines 84% Haematitie ore	C1 + C2	73	55
Dave-Sonal	Magnetite (+haematite) bearing low grade ore-50% Weathered friable and hard BMQ 27% and laterlitised ore 23%	51%	144	36
Salpi-Badrock Signa-Kodal & Salili-Buipal	Magnetite (+haematite) bearing low grade ores Weathered friable and hard BMQ	C2	50	(20-40) 30
Gavenem-Balcornem	Magnetite (+haematite) bearing low grade ores 45% Weathered friable and hard BMQ 28% Lateritised ores 27%	C2	70	(20-50) 30
Conquerim-Sakorda	Lumpy ores 25% Ore fines 75% Haematite ore	C2	48	50-63
Costi-Codli-Dabal-Costi	Lumpy ores 30% Ore fines 75% Haematite ore	C2	80	50-63
Tatodi-Binbol	Lumpy ores 20% Ore fines 80% Haematite ore	C2	35	50-63
	Magnetite ores (Magnetite + haematite bearing weathered BMQ	C2	100	(20–40) – 35

Dudal-Mavlinge, Tolem-Motto, Barazon-Villian	Lumpy ores 80% Ore fines 20% Haematite ores	C2	35	50-63
	Magnetite (+ haematite) bearing weathered BMQ	C2	350	(20-40) ~35
Other deposits (Srigal-Argod, Rivona-Columba Navelim. Vichundre, Netrali, Betul)	Lumpy ores 85% Ore fines 15% Haematite ore	C2	32	50-63
Gross Total	**Haematite and magnetite- (+Haematite) ores**	**C1+C2**	**2006**	**All grades**

Source: GSI, 1996

Annexure 2.3. Mine-wise and village wise iron ore reserves (Million tonnes)

Company	Village	In-situ	Recoverable	R/P Ratio (as in 1996) years*
Cluster I				
Dempo	Mulgao	10 9	9.1	91
D Mangalji	Advolpale	2.1	1.5	15
Bandodkar	Sirigao	31.3	26.1	27
Chowgule	Sirigao	6 7	5.0	27
Chowgule	Maem	17 1	12.8	239
Dempo	Lamgao	3 4	2.9	4
Dempo	Bicholim	1 1	1.0	2
Dempo	Bordem	1.5	1.3	8
	Total	74.1	59.7	413
Cluster II				
V S Salgaonkar	Cudnem	5.5	5.0	12
Timblo	Cudnem	2 3	1 8	7
Sesa Goa	Cudnem	1 3	0 9	2
V S Salgaonkar	Surla	9.8	8 8	11
Dempo	Surla	11.7	9 4	15
V S Salgokar	Velguem	4 1	3 7	21
D B Bandodkar	Velguem	7 1	5 5	8
Chowgule	Pale	17 0	14 6	22
D B Bandodkar	Pale	20 4	18 4	47
V S Salgokar	Pale	5 2	4 7	94
	Total	84 4	72 8	239
Cluster III				
Fomento	Singao	4.4	3 5	19
Sovi	Sangod	4 4	3 5	4
Dempo	Cormonem	6 2	5 0	10
Sea Goa	Codli	82 8	62 3	21
Fomento	Santona	5.1	4 1	10
Chowgule	Santona	5 9	4.7	8
Chowgule	Costi	6.7	5.4	55

	Total	116	88.5	127
Cluster IV				
R S Garco	Patiemetuto	5 6	4.5	9
Chowgule	Tudou	5.2	4 7	16
R S Garco	Tudou	1 4	1.1	14
	Total	12.2	10.3	39

Source: IBM

* Estimated

Annexure 2.4: List of leases granted, operating and applied for renewal in the four clusters

	Owner	Village	Taluka	Area in (Ha)	Lease no	Operating in 1996	Applied for renewal, 1997
		Leases granted in the year 1987					
Cluster I							
1	D. Mangalji	BICHOLIM	BICHOLIM	50.125	11/52		#
2	V.S Dempo	CARAPUR	BICHOLIM	100	37/52		#
3	Dempo	LAMGAO	BICHOLIM	100	11/41	*	#
4	Dempo	BICHOLIM	BICHOLIM	99.96	12/41	*	#
5	Dempo	BORDEM	BICHOLIM	99.5	13/41	*	#
6	Dempo	MULGAO	BICHOLIM	99.91	14/41	*	#
7	Dempo	MULGAO	BICHOLIM	99.55	15/41	*	#
8	R. Bandekar	SIRIGAO	BICHOLIM	99.93	4/49	*	#
9	Chowgule	SIRIGAO	BICHOLIM	99.75	5/49	*	#
10	Chowgule	MAEM	BICHOLIM	72.34	13/49	*	#
11	Sesa Goa Ltd.	ADWALPALE	BICHOLIM	99.4	76/52		#
12	Lithoferro Ltd	ADWALPALE	BICHOLIM	47 3	89/52		#
13	G.N. Agarwal	BORDEM	BICHOLIM	46 325	18/54	*	#
14	V.M S.	ADWALPALE	BICHOLIM	59 66	49/54		#
15	Jorge Sequeira	VAINGUINIM	BICHOLIM	97 578	63/57		#
16	Chowgule	MAEM	BICHOLIM	100	73/58		#
Cluster II							
17	V M.S	SURLA	BICHOLIM	73.2463	29/54	*	#
18	V S Dempo	CUDNEM & SURLA	BICHOLIM	65.794	21/54	*	#
19	Timblo Irmaos Ltd.	CUDNEM	BICHOLIM	40.136	92/52	*	#
20	Timblo Irmaos Ltd.	CUDNEM	BICHOLIM	73.734	14/53	*	#
21	Chowgule	PALE	BICHOLIM	83.973	31/53	*	#
22	V.M.S.	PALE	BICHOLIM	94.6	86/53	*	#
23	S.S. Gaitondo	SURLA	BICHOLIM	99.31	98/53		
24	Chowgule	SURLA	BICHOLIM	89	106/53		#
25	Chowgule	SURLA	BICHOLIM	76.859	107/53	*	#

	Owner	Village	Taluka	Area in (Ha)	Lease no.	Operating in 1996	Applied for renewal, 1997
26	D.B. Bandodkar	VELGUEM	BICHOLIM	75.44	62A/52		
27	R.S. Garco	CUDNEM	BICHOLIM	79.53	51/52		#
28	V.M.S.	VELGUEM	BICHOLIM	52.66	62B/52	*	#
29	Madachem Bhat Mine	PALE	BICHOLIM	64.7	8/61		
30	V M.S	VELGUEM	BICHOLIM	34 628	12/55		#
31	Timblo Irmaos Ltd.	PALE	BICHOLIM	90.7	35/55		
32	Timblo Irmaos Ltd.	SURLA	BICHOLIM	35 58	0 00		#
33	D. Mangalji	ARVALEM	BICHOLIM	97.75	33/55		
34	Jorge Sequeira	PALE	BICHOLIM	100	19/57		#
35	G.N. Agarwal	ARVALEM	BICHOLIM	99.8	18/58	*	#
36	V.M.S.	ONDA	BICHOLIM	99.213	40/58		
37	Stalaulicar	CUDNEM	BICHOLIM	97.5474	48/58		#
38	V.S. Dempo	NAVELIM SURLA	BICHOLIM	70.687	17/60		#
39	Guitabala Parulcar	PISSURLEM	SATARI	87.555	55/51		#
40	Chowgule	VAGURIEM	SATARI	62 268	93/53	*	#
41	Jose X. Cosme Da Costa	PISSURLEM	SATARI	68.1	110/53	*	#
42	Ramakanta Xetie & B	PISSURLEM	SATARI	99 47	70/51	*	#
43	Chowgule	ONDA	SATARI	74.61	98/52	*	#
44	Temblo Irmao Ltd.	ONDA	SATARI	26.672	6/55	*	#
45	V.S. Dempo	SONSHI	SATARI	96.6448	5/54	*	#
46	V.S. Dempo	SONSHI	SATARI	90.9542	20/54	*	#
47	V.S. Quenim	SONSHI	SATARI	56.79	16/55	*	#
48	Chowgule	PONOCEM	SATARI	68.665	41/56	*	#
49	N.R.X. Amoncar	VELGUEM	SATARI	86.2134	5/57		
50	Santilal K.	PISSURLEM	SATARI	38.5	37/57		
51	V. Coutinho	SONSHI	SATARI	66.763	19/58	*	#

	Owner	Village	Taluka	Area in (Ha)	Lease no.	Operating in 1996	Applied for renewal, 1997
52	Lithoferro Ltd.	PISSURLEM	SATARI	100	57/59		#
Cluster III							
53	Temblo Irmao Ltd	SIAGO	SANGUEM	93.99	88/52	*	#
54	S. Kantilal	SANCORDEM	SANGUEM	95.29	16/49		#
55	Chowgule	COSTI	SANGUEM	62.7457	22/50		#
56	V M.S.	DUDAL	SANGUEM	90.5359	24/50		#
57	Chowgule	CALEM	SANGUEM	85.78	40/50		#
58	M.S. Talalulikar	SANCORDEM	SANGUEM	50.382	2/51	*	#
59	Chowgule	DUDAL	SANGUEM	82	16/51		
60	Chowgule	COSTI	SANGUEM	100	38/51		#
61	N.S.S. Narvenkar	SANTONA	SANGUEM	99.2	40/51		#
62	R. Poinguincar	DARBANDORA	SANGUEM	99.6	52/51		#
63	Mineira Nacional Lt	SANTONA	SANGUEM	91.09	62/51	*	#
64	Mingoa Sociedade Mi	CODLI	SANGUEM	99.79	69/51	*	#
65	Timblo Irmaos Ltd	CODLI	SANGUEM	82.293	61/53	*	#
66	Timblo Irmaos Ltd	SIGAO	SANGUEM	50.4	87/53		#
67	Vincente Figueiredo	CORMONEM	SANGUEM	99.008	124/53		#
68	Mingoa Sociedade Mi	CODLI	SANGUEM	100	126/53		
69	Timblo Irmaos Ltd	SANGOD	SANGUEM	99.66	143/53		#
70	Shantilal K.	SANCORDEM	SANGUEM	55.3655	39/54		#
71	Aihabai Dessai	CORMONEM	SANGUEM	82.5	41/54	*	#
72	Sovi	SANGOD	SANGUEM	85.72	45/54	*	#
73	Marzook & Cadar Lt	DARBANDORA	SANGUEM	77.7	4/55		#
74	V.M.S.	SIGAO	SANGUEM	70.23	13/55		#
75	Timblo Irmaos Ltd.	DARBANDORA	SANGUEM	98.45	20/55		#

	Owner	Village	Taluka	Area in (Ha)	Lease no.	Operating in 1996	Applied for renewal, 1997
76	Timblo Irmaos Ltd.	CORMONEM	SANGUEM	99.235	22/55		#
77	Sociedade Mineira G	DARBANDORA	SANGUEM	100	38/55		#
78	Sociedade Mineira G	DARBANDORA	SANGUEM	123.958	39/55		
79	Lithoferro Ltd.	SANGOD	SANGUEM	84.37	19/56	*	
80	Nalini Vinaeca Naiqu	SIGAO	SANGUEM	98.2	31/56		#
81	D. Mangalji	SIGAO	SANGUEM	52 506	34/56		#
82	Joao Sequeira	DARBANDORA	SANGUEM	100	43/56		#
83	D. Mangalji	DABAL	SANGUEM	64 3	46/56		#
84	D. Mangalji	SANTONA	SANGUEM	64.66	11/57		#
85	Chowgule	COSTI DUDAL	SANGUEM	20	12/57		
86	Timblo Irmaos Ltd.	CORMONEM	SANGUEM	100	20/57		
87	Velingcar	DARBANDORA	SANGUEM	59 65	24/57	*	#
88	Timblo Irmaos Ltd	CODLI	SANGUEM	40 765	14/58	*	#
89	Damodar m	SANTONA	SANGUEM	92 044	15/58		#
90	Sesa Goa Ltd.	SANTONA	SANGUEM	92 295	39/58		
91	V.M.S.	SANCORDEM	SANGUEM	99.85	42/58		
92	V.M.S.	SIGAO	SANGUEM	58.01	43/58		#
93	Chowgule	SIGAO-CALEM	SANGUEM	79 009	53/58		#
94	Chowgule	SIGAO	SANGUEM	60.5389	70/58		#
95	S Kantilal	CALEM	SANGUEM	100	29/59		#
96	N S Narverncar	SANTONA	SANGUEM	90.95	31/59	*	#
97	Sesa Goa Ltd.	SANTONA	SANGUEM	98.6	64/59		
98	Sesa Goa Ltd.	CODLI	SANGUEM	99.7952	70/52	*	#
99	Timblo Irmaos Ltd.	CALEM-SIGAO	SANGUEM	74.89	10/60		
100	D. Mangalji	CORMONEM-CALEM	SANGUEM	100.1	15/60		
101	Shantilal K.	CORMONEM	SANGUEM	29.3886	24/60		#

	Owner	Village	Taluka	Area in (Ha)	Lease no.	Operating in 1996	Applied for renewal, 1997
102	Maria Seani Rapheal	CALEM	SANGUEM	83.2	6/41		#
103	Empresa Minerio Com	CALEM	SANGUEM	97.3	7/41	*	#
104	G N. Agarwal	CALEM	SANGUEM	100	8/41	*	#
Cluster IV							
105	S. Kantilal	BATI	SANGUEM	98.315	29A/56		#
106	S. Kantilal	BATI	SANGUEM	84.5	30/56		#
107	S. Kantilal	BATI	SANGUEM	97.94	36/56		#
108	S. Kantilal	BATI	SANGUEM	84.2	49/56		#
109	R.S Garco	PATIEM- TUDOU	SANGUEM	100	3/57	*	#
110	S. Kantilal	BATI	SANGUEM	116.772	32/57		#
111	R.S. Garco	TUDOU	SANGUEM	96.15	33/57	*	#
112	Shantilal K.	POTREM	SANGUEM	53.058	34/57		
113	Chowgule	TUDOU	SANGUEM	91.4	42/57		#
114	Babol Tari	BATI	SANGUEM	41.4	31/58		
115	S Kantilal	BATI	SANGUEM	92.7715	20/60		#
116	Chowgule	TUDOU	SANGUEM	80.46	40/57		#
	TOTAL LEASES GRANTED IN 1987			116			
	TOTAL LEASES OPERATING IN 1996			42			
	TOTAL LEASES APPLIED FOR RENEWAL IN 1997			93			

Source GMOEA, 1996

Annexure 2.5. Cluster-wise details of dry screening plants

	Company	Location of plant	Capacity (tonnes per hour)
	Cluster I		
1.	Chowgule & Co.	Sirigao	250
2.	Dempo	Bicholim	800
	Cluster II		
1	V.G. Quenim	Cudnem	250
2.	Sesa Goa & Co	Sonshi	200
3.	Sesa Goa & Co	Sanquelim	40
4.	Chowgule & Co	Pale	200
5.	V.S. Dempo	Surla	500
6.	D.B. Bandodkar	Cotombi	300
7.	D Mangalji	Pissurlem	300
8.	D. Mangalji	Pissurlem	250
9.	Bandekar	Pale	250
10.	V.M. Salgaocar	Vagus	1000
11.	Salgaocar Mining	Vagus	800
12.	Sesa Goa & Co.	Amone	180
	Cluster III		
1.	Sesa Goa & Co.	Codli	200
	Outside Clusters		
1.	G N. Agarwal	Bimbol	150
2.	Fomento	Maina	500

Source. Department of Mining

Annexure 2.6. Cluster-wise details of wet beneficiation plants

	Company	Location/village	Capacity (lakh tonnes per annum)	Recovery (%)
	Cluster I			
1.	Dempo	Bicholim	3.5	85
2	Dempo	Piligao	9.0	85
	Sub-total		12.5	
	Cluster II			
3	Mangalji	Navelim	2 5	78r
4	Chowgule & Co	Pale	6.0	60
5.	Sesa Goa & Co	Cudnem	10.0	75
6.	D B Bandodkar	Cotombi	3.2	NA
7.	Dempo	Surla	6.1	85
8.	Sesa Goa	Amone	8.0	75
9.	V M. Salgaocar	Vagus	30 0	80
10.	Fomento		NA	-
	Sub-total		65.8	
	Cluster III			
11	R S. Velingkar	Darbandora	4.2	80
12	G N Agarwal	Bimbol	1.3	80
13	Chowgule	Costi	6.0	60
14	Chowgule	Costi	10 0	80
15	Chowgule	Bimbol	2.0	NA
16	Sesa Goa	Codli	15.0	75
17	Sesa Goa	Codli	10 0	75
18	Sesa Goa	Codli	9.0	75
19	V S Dempo	Kirlapale	3.5	75
20	Resources International	Codli	7.5	68
21	Sesa Goa	Xelpi	6.5	80
22	Salgaokar	Talodi	11.2	60
	Sub-total		86.2	
	Cluster IV			
23.	Chowgule	Barazon	5.5	
	Total		170.0	

Annexure 2.7. Cluster wise details of barge loading points

Company	Loading Point	Village	Capacity Mt/a	River	Mines Served	Distance from mines (Km.)
Cluster I						
Dempo	Sarmanos	Piligao	1.85	Madei	Bicholim	5
R Bandekar	Sirsaim	Adwallpale	0.57	Assnora	Siringao	5
Chowgule	Kalvi	Siringao	0.27	Mapusa	Siringao	5
Cluster II						
Chowgule	Khazan	Cotombi	0.99	Madei	Pale	7
					Bimbol	33
					Vaguriem	12
					Onda	17
Sesa Goa	Amone	Amone	0.87	Madei	Sonshi	9
					Cudnem	8
					Xelpi	20
Bandekar	Kotambi	Cotombi	1.33	Madei	Mollo	7
					Madachem Bhat	7
D Mangalji	Kotambi	Cotombi	1.33	Madei	Ceavan dongor	14
D Mangalji	Navelim	Navelim	1.03	Madei	Band dhonkol	8
					Deulem	8
V S Dempo	Sinori	Surla	0.86	Madei	Surla	6.5
					Sonshi	4
V M Salgoakar	*Vaguriem*	Cotombi	2.00	Madei	Velguem/Surla	11
					Sigao	27
					Sancordem	29
					Cudnem	15
Sallitho	*Vaguriem*	Cotombi	2.00	Madei	Purmar	7
V G Quenim	*Vaguriem*	Cotombi	2.00	Madei	Sonshi	11
Timblo	Maina	Cotombi	2.00	Madei	Dignem	6
Cluster III						
Sesa Goa	Sanvordem	Sanvordem	2.77	Zuari	Codli	12
R S Gharse	Sanvordem	Sanvordem	2.77	Zuari	Molia dongor	54
Dempo	Sanvordem	Sanvordem	2.77	Zuari	Kirlapale	12
Chowgules	Xelvona	Sanvordem	1.31	Zuari	Tudou	30
					Costi	16
					Kalay	13

Chowgules	Capxem	Sanvordem	1 33	Zuari	Emco	38
					Emco	26
Foments	Capxem	Sanvordem	1 33	Zuari	Chiraband	23
				Zuari	Sigao	22
Timblo	Capxem	Sanvordem	1 33	Zuari	Nassarmordi	51
R S Gharse	Capxem	Sanvordem	1 33	Zuari	Tollem	55
Mineira Nacional	Digashi	Sanvordem	1 33	Zuari	Cuddegalivoril	11
S Kantilal	Digashi	Sanvordem	1 33	Zuari	Shanti Group	23

CHAPTER 3

Present status of environmental quality

This chapter deals with the existing status of environmental quality of the study area which includes ambient air quality, water quality, forest, land and soils.

Introduction

The decade of 1970s witnessed a phenomenal growth in the iron ore production in Goa. By the end of 1970s, the production and export had increased to about 13 million tonnes and the industry shifted its priority of mining lumpy ore to deep seated iron rich powdery ore horizons. This was achieved through mechanized opencast mining system supported with dry screening facilities. In the 1980s the production remained between 11-13 Mt/a but in the 1990s it has increased to about 15 Mt. The increased production of iron ore over the years has resulted in increased overburden removal, transportation activities, setting up of a number of dry screening plants and wet beneficiation plants and workshops and garages for vehicle repair and maintenance. The associated increase in population in the area has resulted in increase in public transport and other commercial and infrastructural establishments. This growth in economic activities has, however, been accompanied by a deterioration in the quality of environment (air, water and land), particularly in and around the mining areas. The generation of residuals and impact on land and water bodies have increased significantly in the last two decades causing severe environmental problems in the area.

Unique features of iron ore mining in Goa

The mining industry in Goa has had a number of positive and significant impacts on the economic development of the State. There have, however, also been several environmental impacts, some of which are due especially to the unique features of mining in Goa and some due to bad mining practices and poor environmental management The iron ore industry operates under certain difficult conditions specific to Goan iron ore mines These include market forces which control iron ore demand and price and technical features which affect the mining operations The major technical difficulties encountered are given below

- Concentration of marketable ore being confined to relatively smaller area in Goa when compared to other parts of India
- Restricted lateral development due to smaller areal extension since the lease area of individual mines is about 100 hectares or less
- High overburden to ore ratio of an average of about 2 5 1 implies that a large amount of overburden is generated when ore is extracted. Since the mining leases are less than 100 hectares, there is very limited space or none at all available within the lease area to dump

the waste material. This leads to acquiring land outside the lease area for dumping rejects.

- Land being in short supply, dumps are typically steep with slopes greater than 30° and heights of 30-50 metres. Many waste dumps are situated in the upper part of the valley regions and during monsoon, run off from the dumps is common which blankets agricultural fields and settles in water courses.
- Transport problem within the mine due to greater depth of workings.
- Restricted drilling and blasting due to presence of villages and inhabited areas in the vicinity of the mines.
- Mining activity in several places is being carried out below the water table which requires dewatering of pits for operations to continue.
- Because of small holdings, large amount of ore is blocked in barriers of adjoining mines Operations could be carried out close to common boundaries of two lease holders with mutual understanding. In such cases, development in one area has to be necessarily accompanied by development in the other area.

Climate

The general climate of the area is mainly tropical and is influenced to a large extent by the conditions in the Arabian sea. There are four seasons, viz. winter (December to February), summer or pre-monsoon (March to May), monsoon (June to September and post monsoon (October to November). The climate is characterized by high humidity and less extremes of temperature. The temperature varies between 20 to 33° C. The annual rainfall varies from 2700 mm to 3500 mm and the approximate number of rainy days are 110 The bulk of the rainfall is received during the SW monsoon (June to October) The average relative humidity is between 70-90%. Month-wise rainfall data for the last 10 years for North and South Goa is presented in Annexure 3.1a and Annexure 3 1b. The rainfall during the last three years is also presented in Figures 3 1& 3.2 As can be seen from the tables and figures, the maximum rainfall is recorded in the month of July Wind-rose diagrams for summer, post-monsoon and winter season are given in figures 3 3 to 3 14 The predominant wind direction for summer, post-monsoon and winter seasons are reported to be SW-SE-N, S-SW and E-NW-W, respectively

Figure 3.1 Rainfall for North Goa

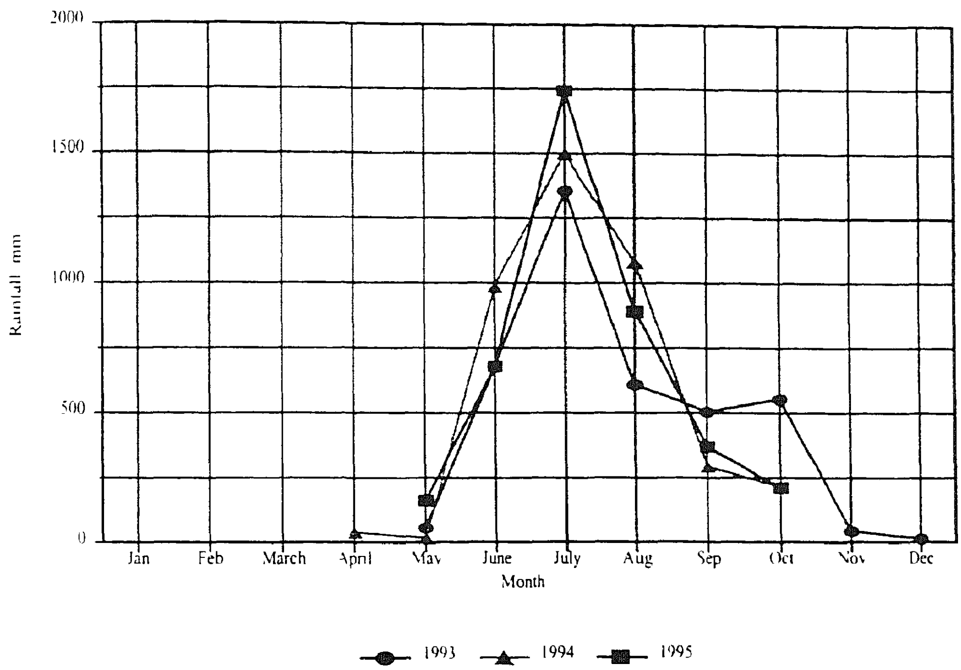


Figure 3.2 Rainfall for South Goa

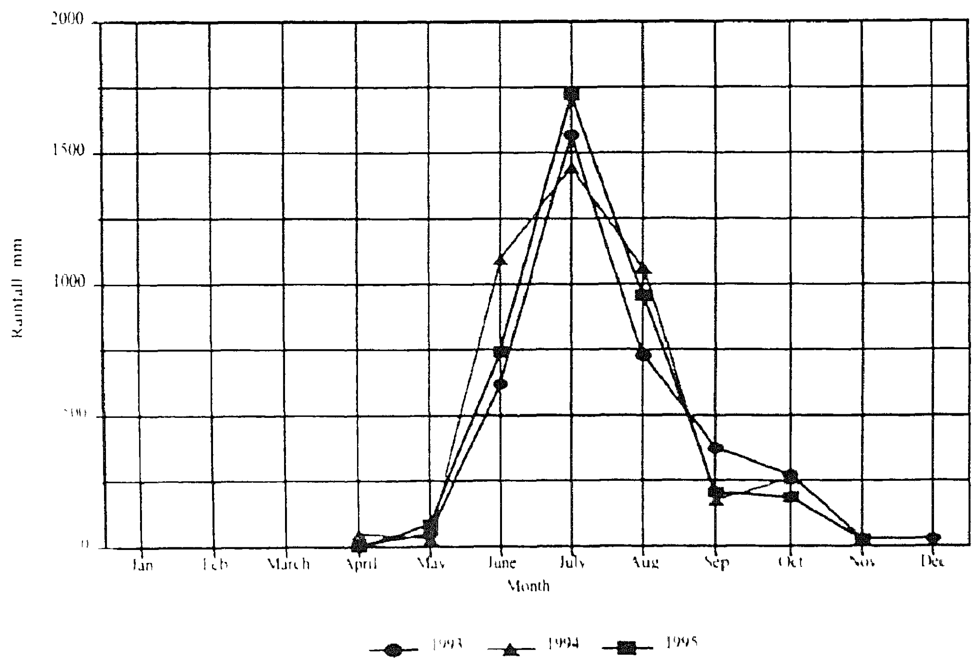


Figure 3.3 Wind - rose diagram for North Goa

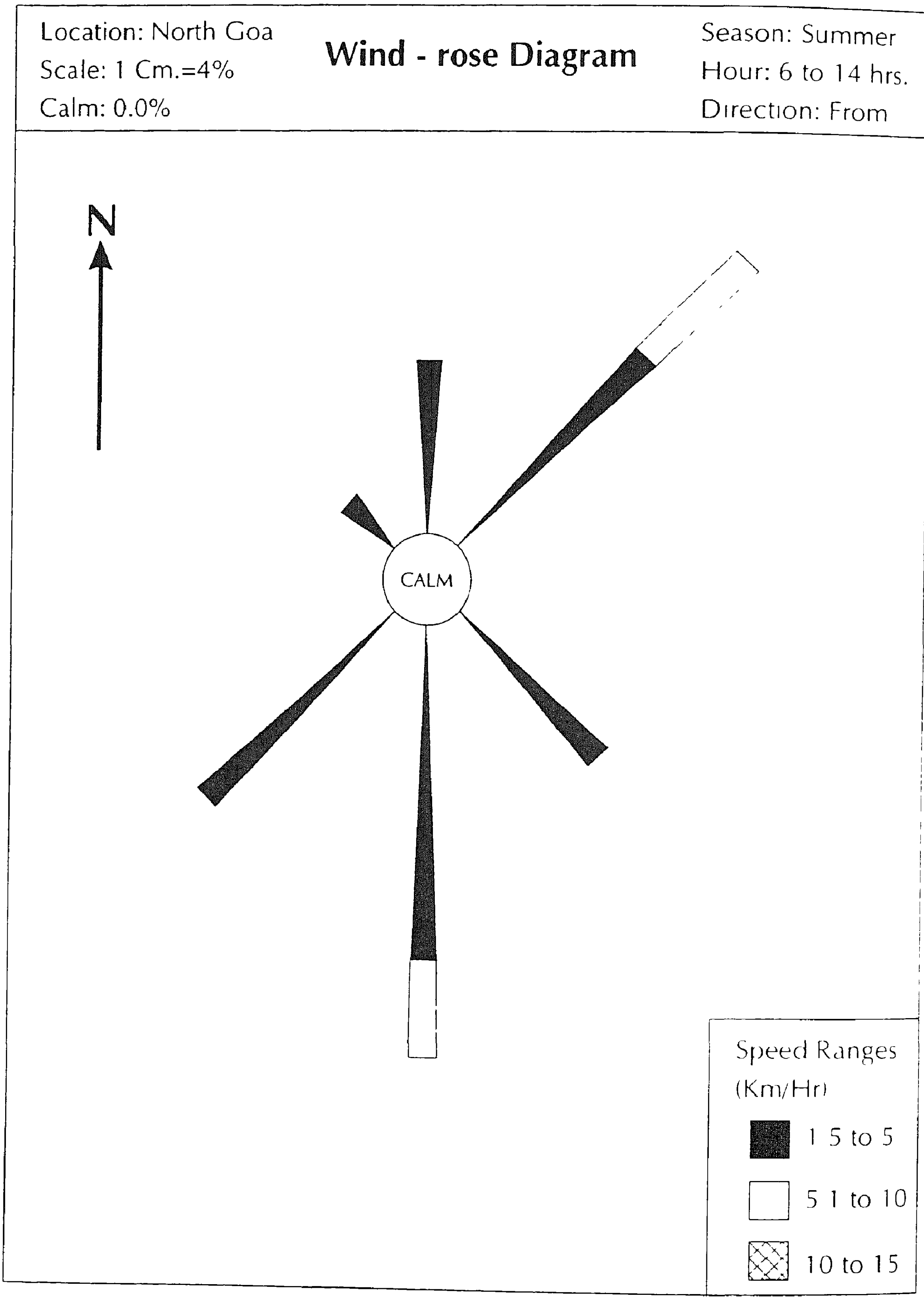


Figure 3.4 Wind - rose diagram for North Goa

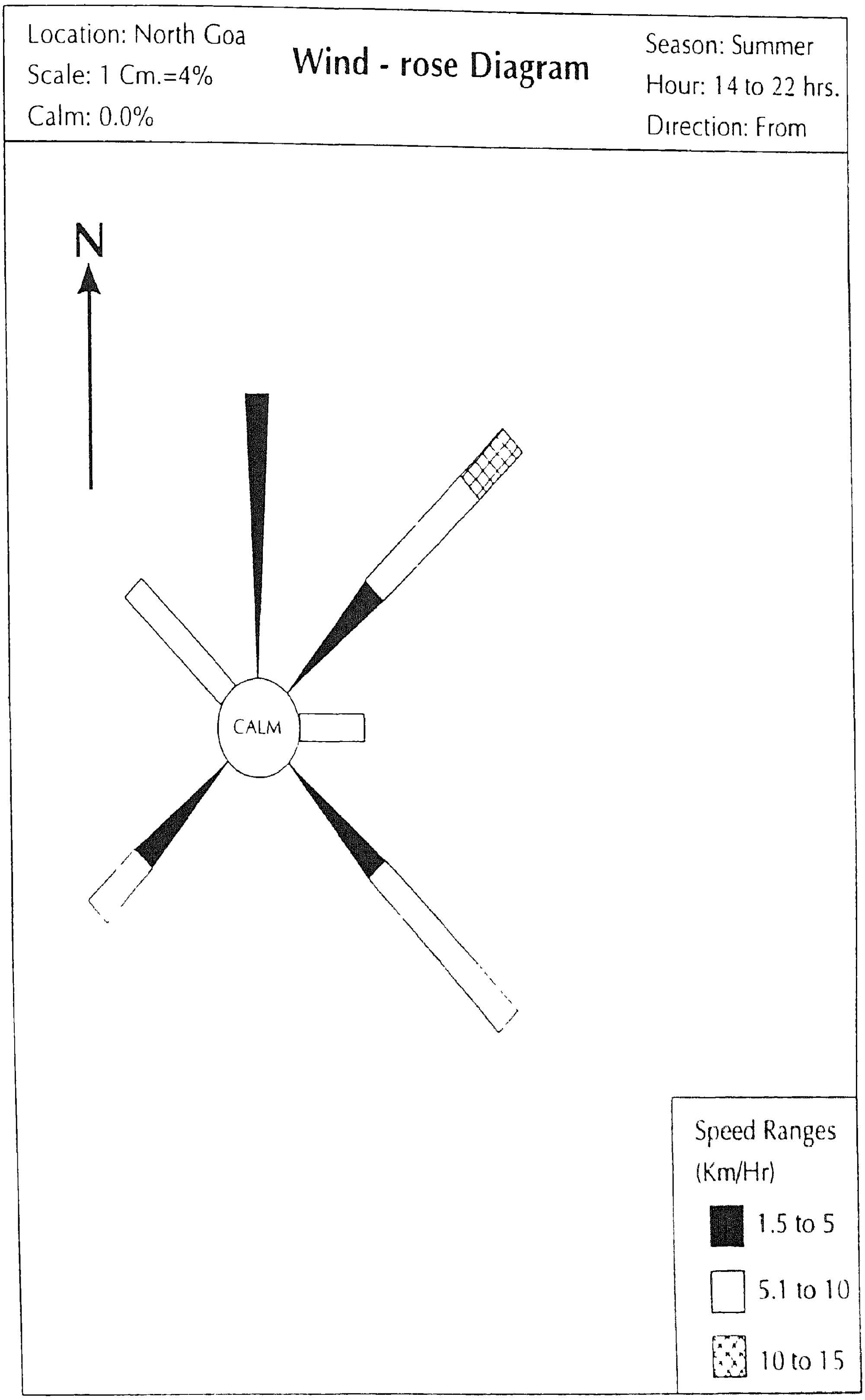


Figure 3.5 Wind - rose diagram for North Goa

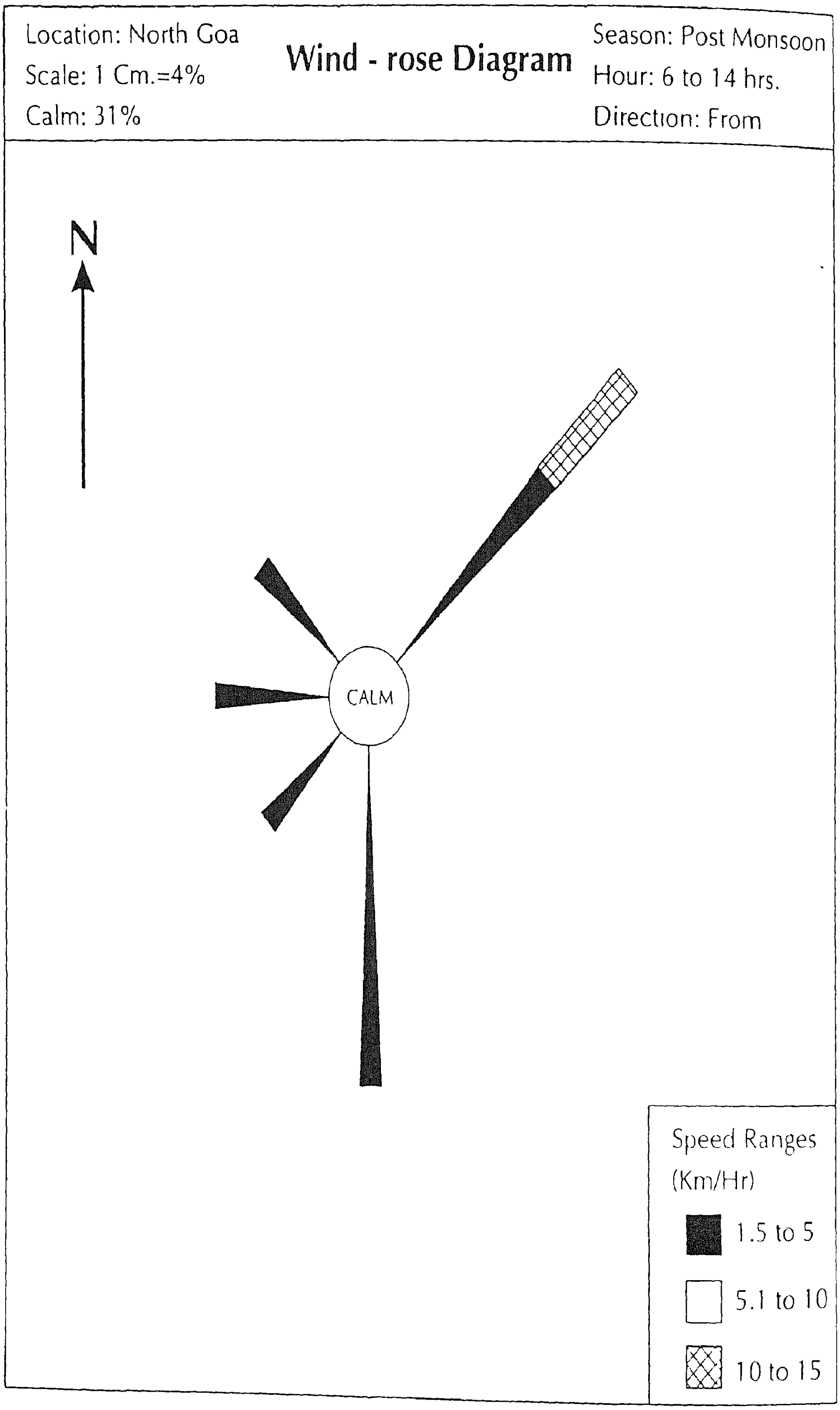


Figure 3.6 Wind - rose diagram for North Goa

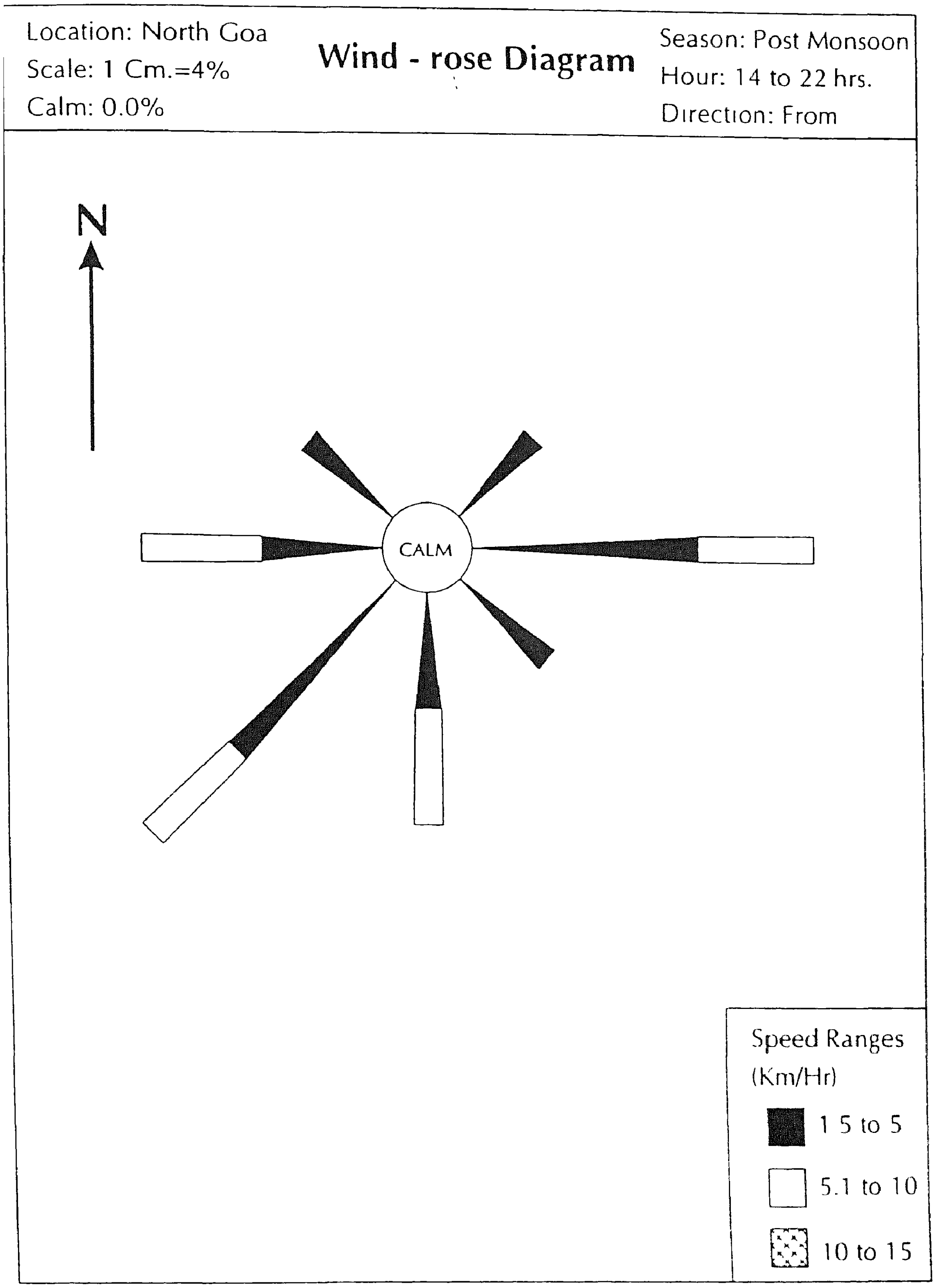


Figure 3.7 Wind - rose diagram for North Goa

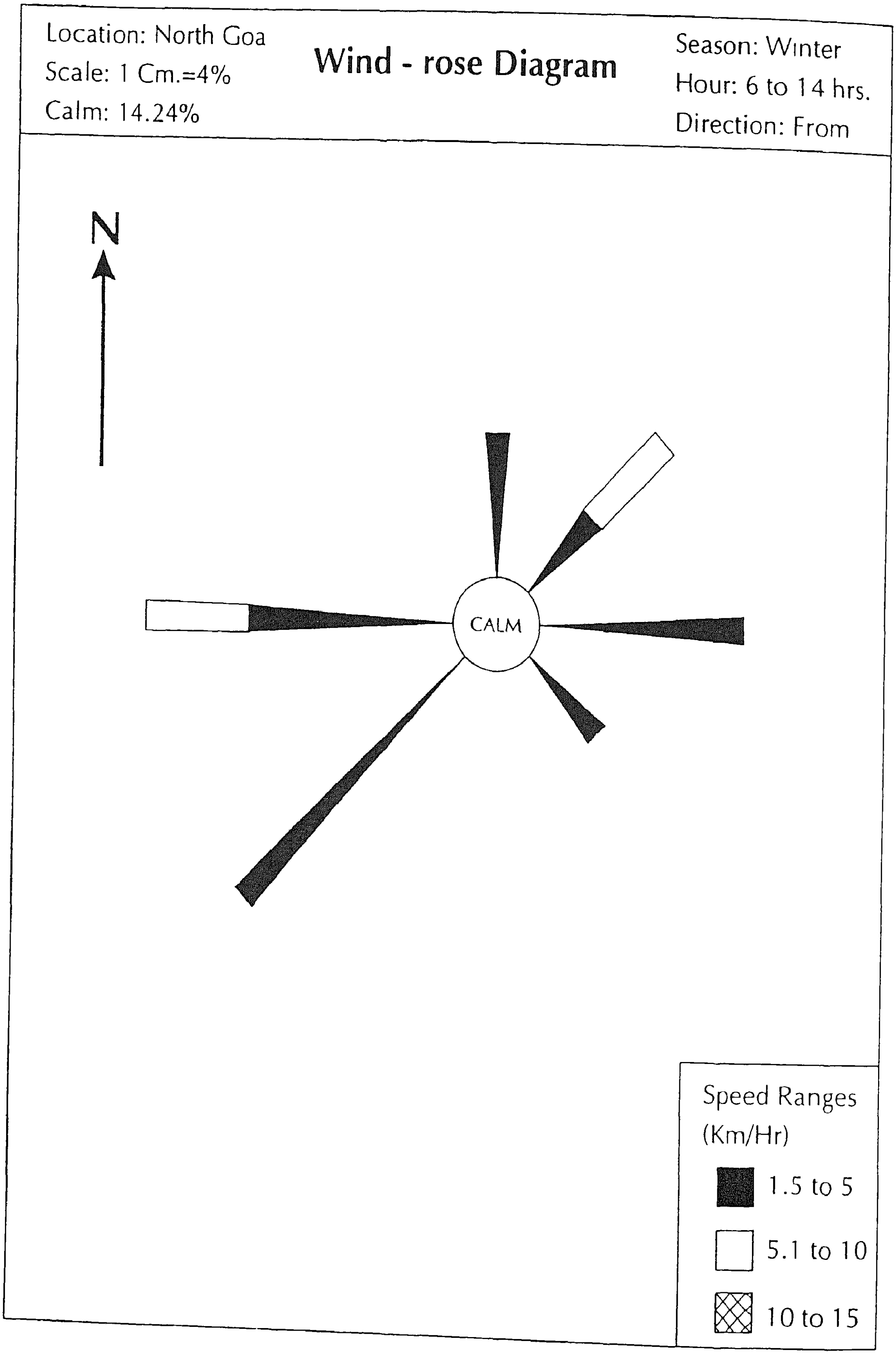


Figure 3.8 Wind - rose diagram for North Goa

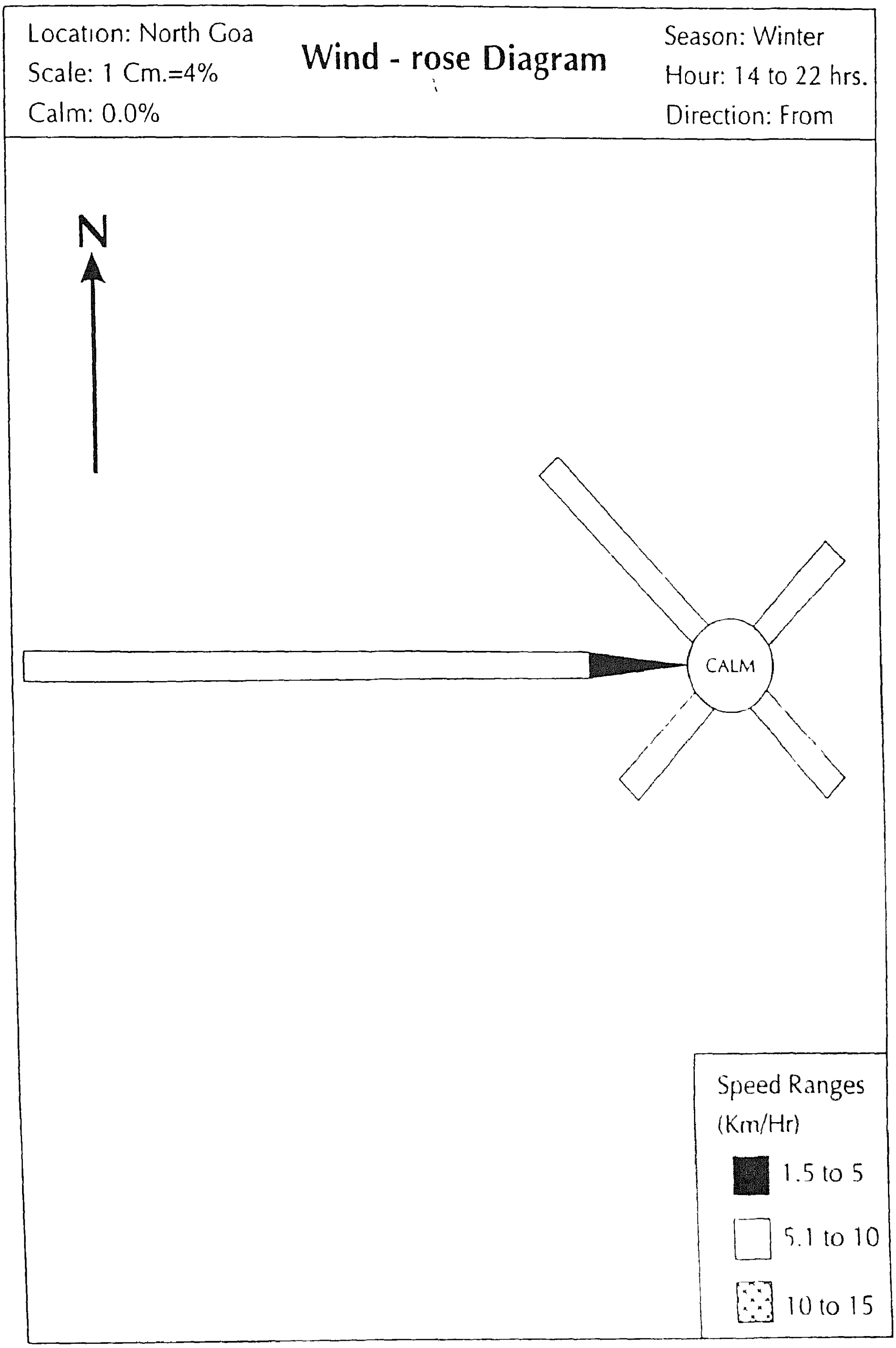


Figure 3.9 Wind - rose diagram for South Goa

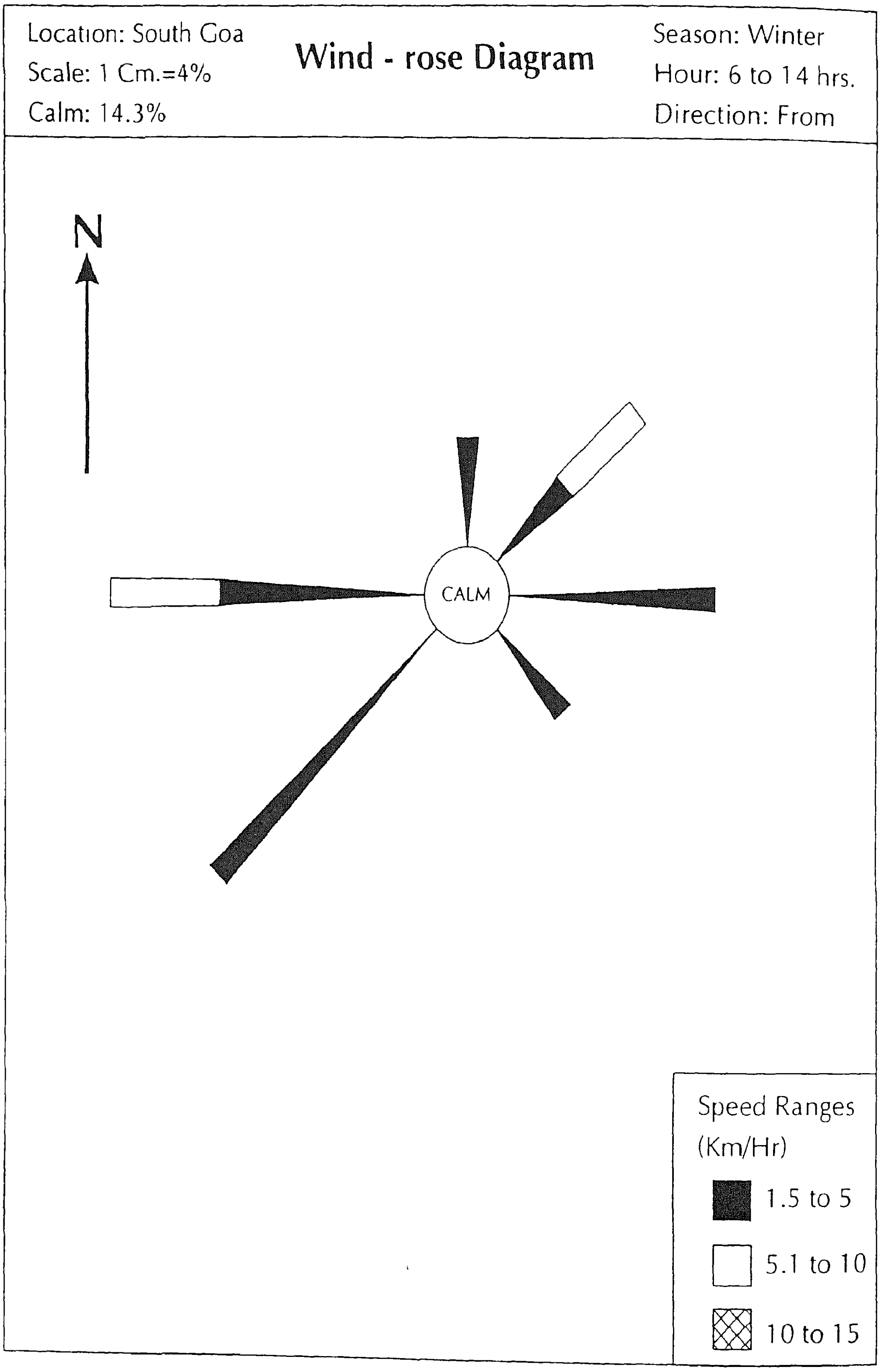


Figure 3.10 Wind - rose diagram for South Goa

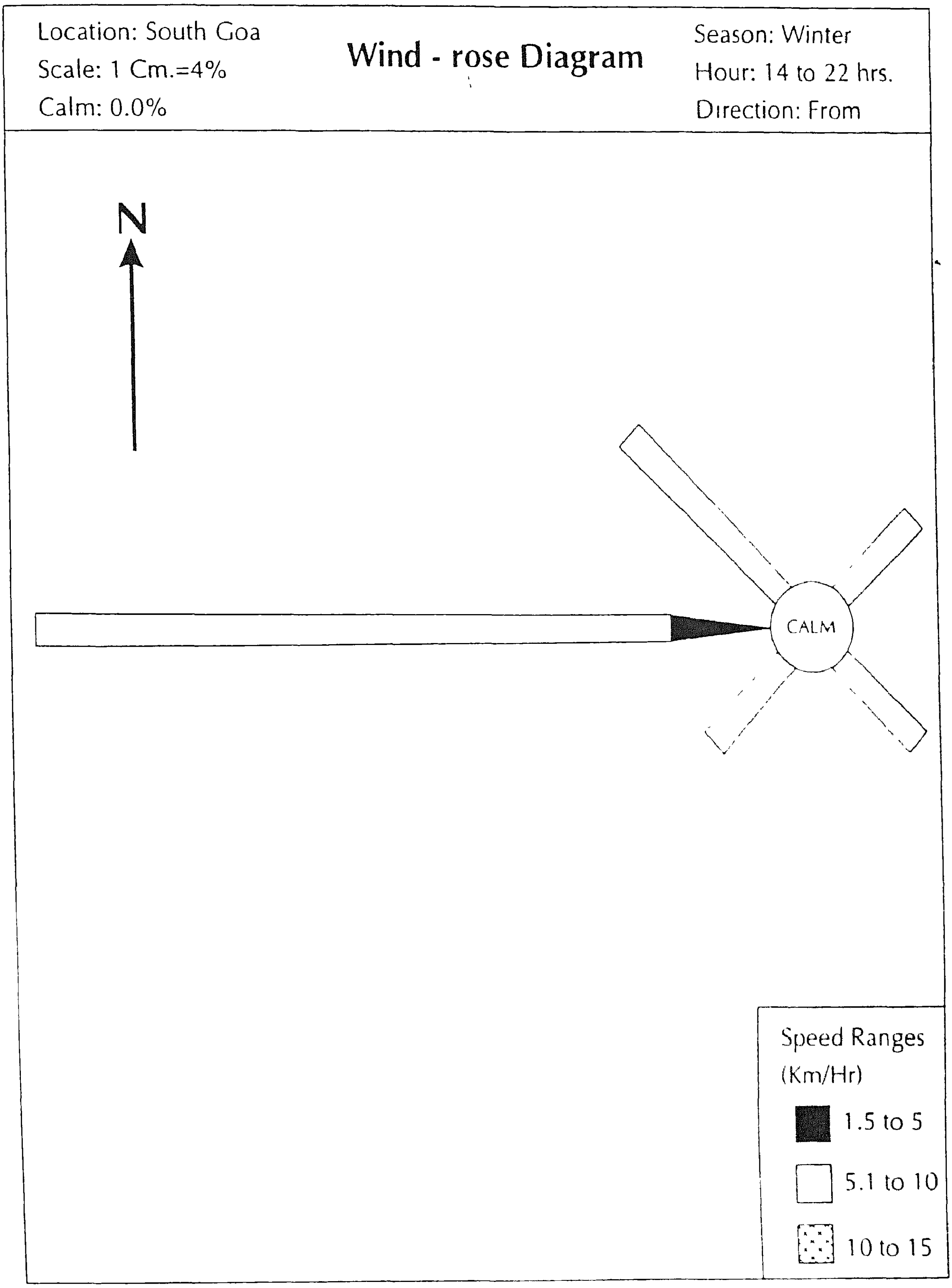


Figure 3.11 Wind - rose diagram for South Goa

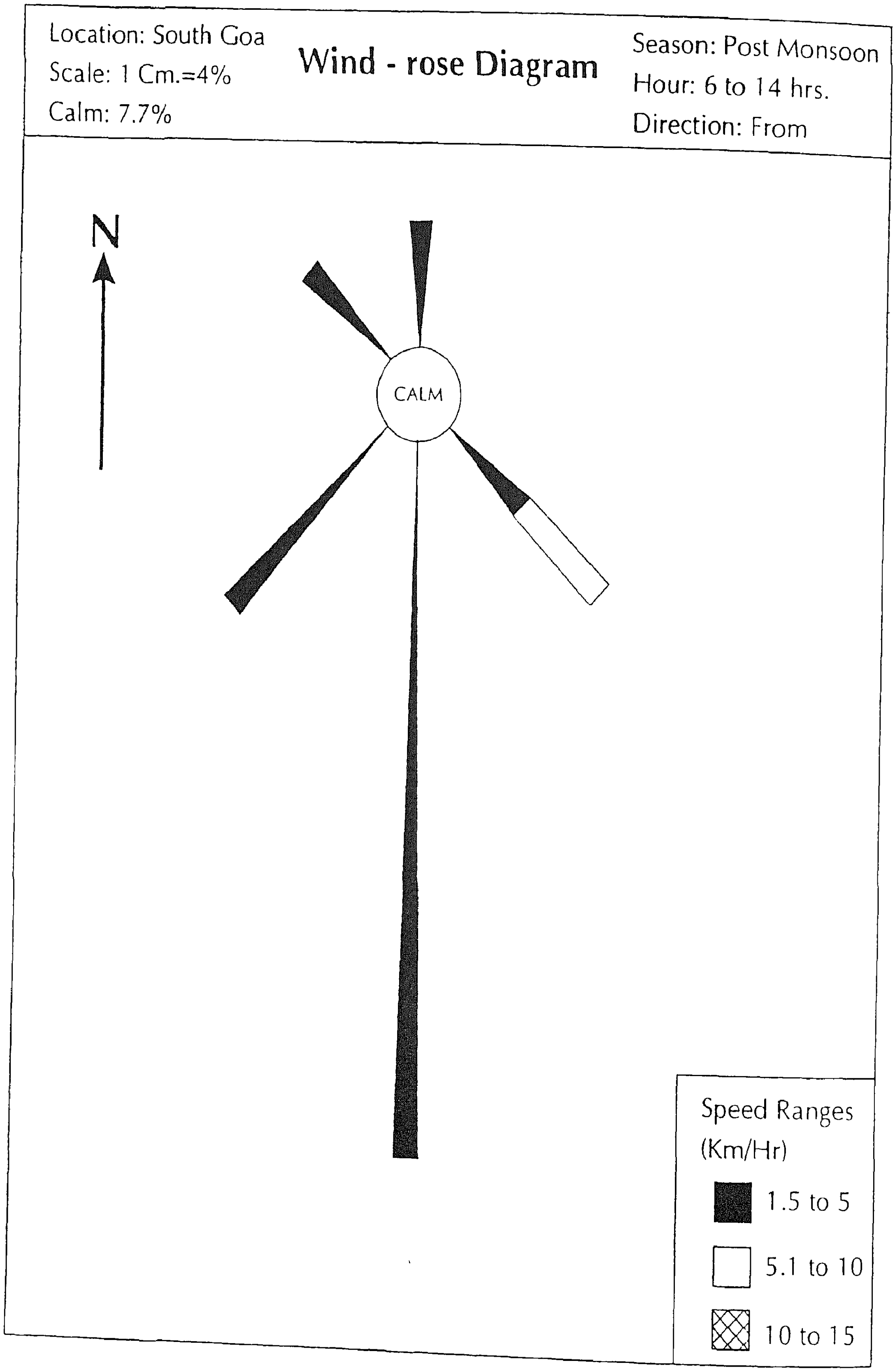


Figure 3.12 Wind - rose diagram for South Goa

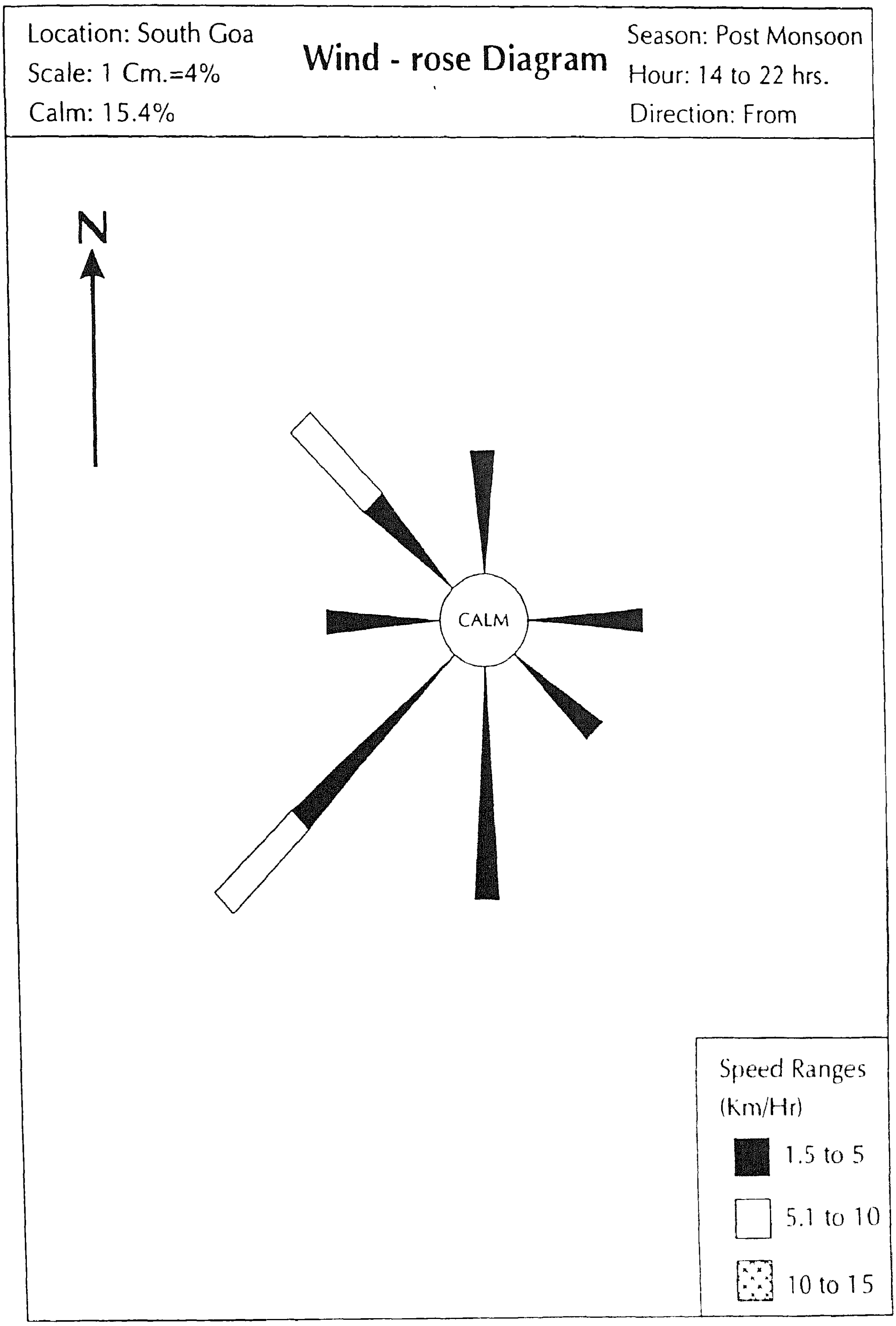


Figure 3.13 Wind - rose diagram for South Goa

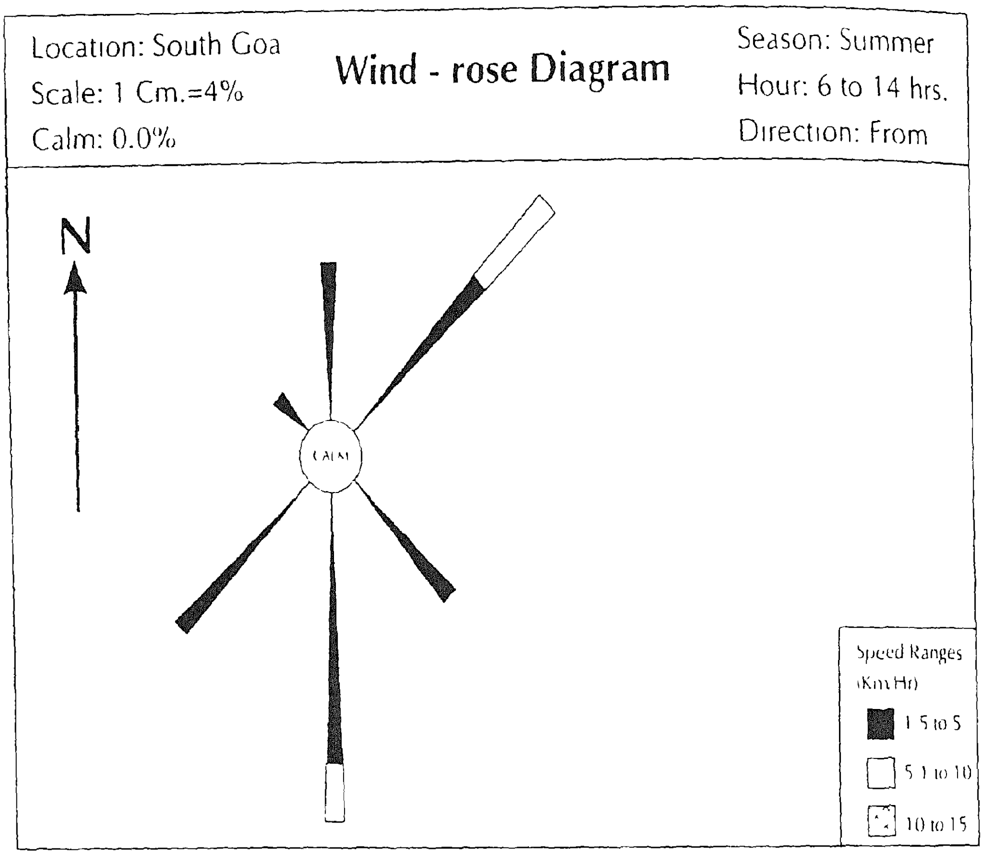
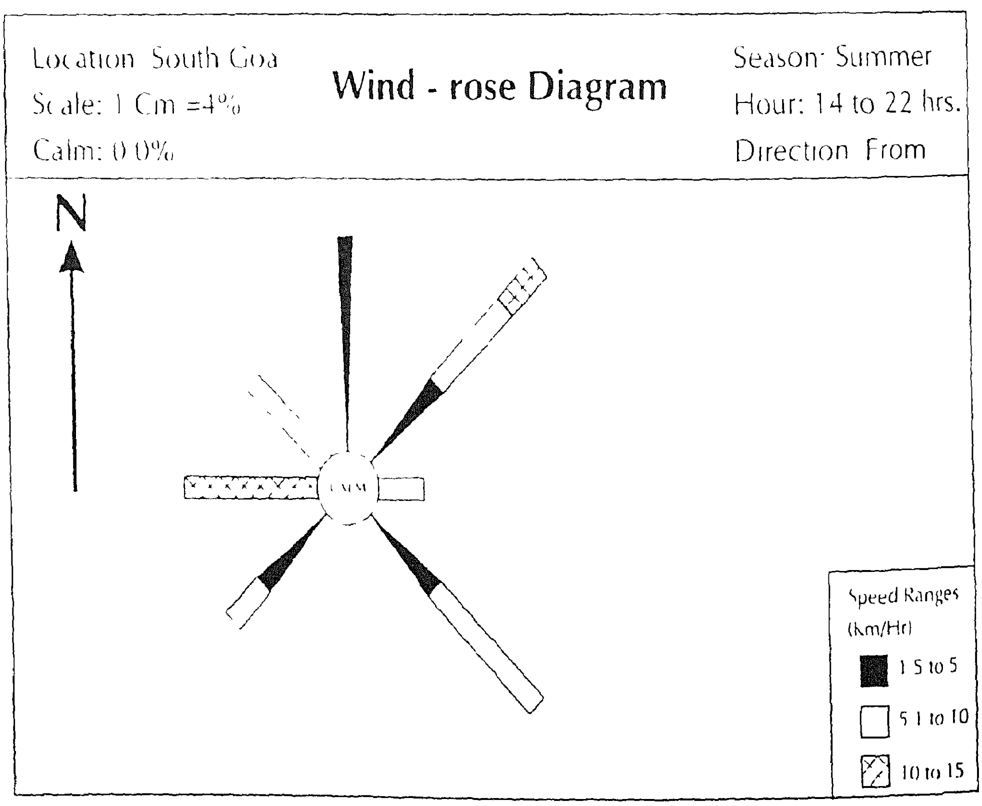


Figure 3.14 Wind - rose diagram for South Goa



Topography and drainage

The central part of Goa comprising of the mining belt, extends from northwest to southeast, through Pernem, Bicholim, Ponda and eastern parts of Sanguem and Quepem. It is characterized by uplands with undulating topography and gentle to moderate slopes, intercepted by concave depressions and valleys, which are mainly under paddy cultivation The slope gradients range from 5° to 20° and occasionally go up to 30°. Zuari and Mandovi are the two major rivers traversing the study area, the basins of which cover about 2500 sq km or 68% of the total land area of the State. The basins support 55% of the states population and covers two-thirds of the area under mining activity Their main tributaries in the study are Madei, Valvent, Khandepar, and Assonora.

Environmental quality of the study area

Characterization of the environmental situation has been organized according to the three types of pollutant receptors namely, land, air and water

Land

Perhaps the most serious impact of mining operations is on the land environment The extent of land degradation however, varies and is influenced by the topography of the area, geology, nature of soil and method of mining Even though iron ore mining in Goa has been going on since the fifties, there was a spurt in ore production during the seventies which has caused considerable land degradation. The damaged land adversely affects water courses, vegetation and animal communities. Land is required for (I) mine excavation (pit); (ii) waste dumping, (iii) ore stackyard, (iv) infrastructure facilities like, beneficiation plant, road, office building, and workshop; and (v) residential colony. Since the ore to overburden ratio in the mining belt of Goa ranges from 1:2.5 to 1:3, an enormous amount of waste material is generated per tonne of iron ore mined Since adequate land is not available for proper dumping, the dumps are typically steep and high (upto 50 metres). Due to paucity of dumping area, in many mines dumping often is done outside the leasehold area. In addition to the waste material, there are many dumps containing mineral rejects from the mines. These include low grade lumpy ore, low grade aluminous powdery ore (Fe content varies from 53-59% and Al_2O_3 4-7%) and low grade siliceous powdery ore (Fe 49-50% and SiO_2 28%) Sometimes this friable siliceous rejects, after screening are utilized for blending, as they contain very low alumina content (Al_2O_3 1-2%). The quality and quantity of various types of iron ore rejects, dumped in the mine are not available. A large quantity of these rejects may be lost due to runoff over the years

Cluster wise land utilization pattern (based on Census data)

The cluster wise land utilization pattern in the study area based on census data (1991) is given in Table 3.1. For comparison, the land use pattern in the state of Goa is also given in the table. Area not available for cultivation includes land degraded due to mining and other causes,

settlements, buildings, etc. Other uncultivated land includes pastures, grazing land, cultivable waste including fallow land and land under miscellaneous tree crops.

Table 3.1. Cluster-wise land utilization pattern (in sq km)

Land use	Cluster I	Cluster II	Cluster III	Cluster IV	Total	Goa
Total area	66	122	235	77	500	3611
Area under forest	nil	5 (4%)	78 (33%)	47 (61%)	130 (26%)	1255 (35%)
Area not available for cultivation	21 (32%)	34 (28%)	34 (14%)	4 (5%)	93 (19%)	371 (10%)
Other uncultivated land	7	28	15	5	55	604 (17%)
Net area sown	38	55	108	21	222	1381 (38%)

Source: Census of India (1991)

As can be seen from the table, the forests are practically non-existent in the villages of cluster I and occupy only 4% of the land area in cluster II. In cluster III and IV they occupy large areas of land. Agriculture is the single most important land use in cluster I, II and III. The share of irrigated area as a percent of total cultivated area is only about 8% in clusters I and II and less than 3% in clusters III and IV. The areas not available for cultivation, which include land damaged due to mining and associated activities, are high in clusters I and II and very low in cluster IV. This is because mining operations have been concentrated in North Goa in the past and only in the last decade or so mining is increasing in South Goa

Cluster wise land utilization pattern (based on aerial photographs and satellite imagery)

Remote sensing techniques have been made use of to study the land use pattern and their changes over 1988 - 1997 period. Both aerial photographs and satellite imageries help to demarcate the mining related features and other land cover details and their changes over a period of time. A detailed assessment of land use pattern in all the clusters has been carried out using aerial photographs available for January 1988. Aerial photographs of the study area have been selected using the flight line map and making a loose mosaic of aerial photographs. These aerial photographs were interpreted using mirror stereoscopes and overlays were prepared for every alternative stereopairs. Base maps were prepared for each cluster at 1:25,000 scale from Survey of India toposheets of the same scale. The interpreted overlays at 1: 10, 000 scale has been transferred to base maps at 1:25,000 scale using optical reflecting projector (Kargil). The 'X' and 'Y' shift in aerial photographs has also been taken care of while transferring the details to the base maps through optical reflecting projector. The mine pits, dumps (ore and waste), beneficiation plant, tailings pond, stockyard (including loading points), wetland agriculture

(paddy fields), mixed crops (plantations, orchards and other crops),vegetation (both natural forests and other man made forests), built up area (settlements and other developed area), degraded land (barren and degraded due to human activities), roads and drainage have been demarcated from the aerial photographs

The compiled map for each cluster has been digitised, edited and transformed for further analysis using ARC/INFO geographical information system(GIS) The area statistics for each of the land use categories have been generated and tabulated for each cluster. In addition, village wise land cover use statistics have also been tabulated to find the variations among the villages

At the second stage satellite imageries of IRS-1C Panchromatic sensor having 5 8 m resolution has been procured from National Remote Sensing Agency (NRSA) for the current year(1997) These imageries have been selected since they have a very high resolution The geocoded satellite imageries at 1:12,500 scale have been procured to have a near matching scale of aerial photographs to reduce the errors arising out of non-stereoscopic visual interpretation of satellite imageries In addition, errors in visual interpretation of satellite imageries has been minimised through the conjunctive use of topographic sheets and aerial photo interpreted overlays The geocoded satellite imageries were for the period of January 1997- April 1997 to get cloud and haze free imageries. The overlays were prepared by the visual interpretation of satellite imageries and digitised to transform into ARC/INFO GIS domain The land use type wise area statistics were generated and tabulated for each of the clusters and also for individual villages The land cover statistics for 1988 and 1997 has been analysed to find out the changes over that period.

The cluster wise details of land use pattern for 1988 (January) and 1997 are given in Table 3.2. The land cover maps (as in 1997) for the four clusters are given figures 3.15 to 3 18

Interpretation of the land utilization data

There has been an increase of about 900 hectares under mine pits and dumps; the major increase is in cluster III (354 ha) and cluster II (307 ha). The mining activity has been concentrated in these two clusters in the last decade There has been a marginal increase of about 110 ha in cluster I and 125 ha in cluster IV Mining activity is declining in cluster I and is being started/expanded in cluster IV The area under tailings pond for beneficiation plant rejects has increased by 115 hectares, 80% of which is in cluster - III The area under vegetation cover (generally forests) has declined by 2500 ha, 70% of which is in cluster III and IV where the forests cover is more In cluster I, there is no forest cover and in cluster II also area under forests cover is declining rapidly This also tallies more or less with the current data Table 3 1. The area under wetland agriculture has declined by about 500 ha but the area under mixed crop has increased substantially by 1860 ha

The area under degraded land has reduced by about 1000 ha and probably has been brought under settlement and mixed crops. These interpretations are only indicative and the numbers are not exact. The cluster wise and village wise land use are pattern (as in 1997) are given in Annexure 3.2.

Table 3.2. Changes in land use pattern over 1988 - 1997 (in hectares)

	Cluster I			Cluster II			North Goa 1997	Cluster III			Cluster IV			South Goa 1997	Total study area
	1988	1997	Change	1988	1997	Change		1988	1997	Change	1988	1997	Change		
Mine related															
Mine pit	185	256	71	477	716	239	972	356	533	178	37	103	66	637	1609
Dumps	154	193	39	531	599	68	792	252	428	176	22	81	59	509	1301
Beneficiation plant	26	32	5	33	68	35	100	15	16	1	0			16	116
Tailing pond	13	15	2	51	75	24	90	25	114	89	0			114	205
Stockyard	18	18		109	100	-9	118	0		0	0		0		118
Mine area total	396	514	118	1201	1558	358	2072	648	1092	444	59	184	125	1276	3349
Other															
Mixed crop	5404	6127	723	7105	7408	303	13534	9179	10506	1327	1112	1730	618	12237	25771
Wet land agriculture	1251	1026	-226	1098	1114	16	2140	1034	839	-195	174	71	-103	910	3050
Built up area	509	441	-68	458	584	126	1025	300	240	-60	17	21	4	261	1286
Vegetation cover	365		-365	705	298	-407	298	10918	9836	-1082	6247	5573	-674	15409	15707
Degraded land	489	329	-161	1759	1361	-398	1689	1259	825	-434	29	60	31	884	2574
Water bodies	187	167	-21	406	410	3	576	40	39	-1	0	0	0	39	615
Subtotal	8207	8089	-118	11531	11174	-357	19263	22730	22286	-444	7579	7454	-124	29740	49003
Total area	**8603**	**8603**		**12732**	**12732**		**21336**	**23378**	**23378**		**7638**	**7638**		**31016**	**52352**

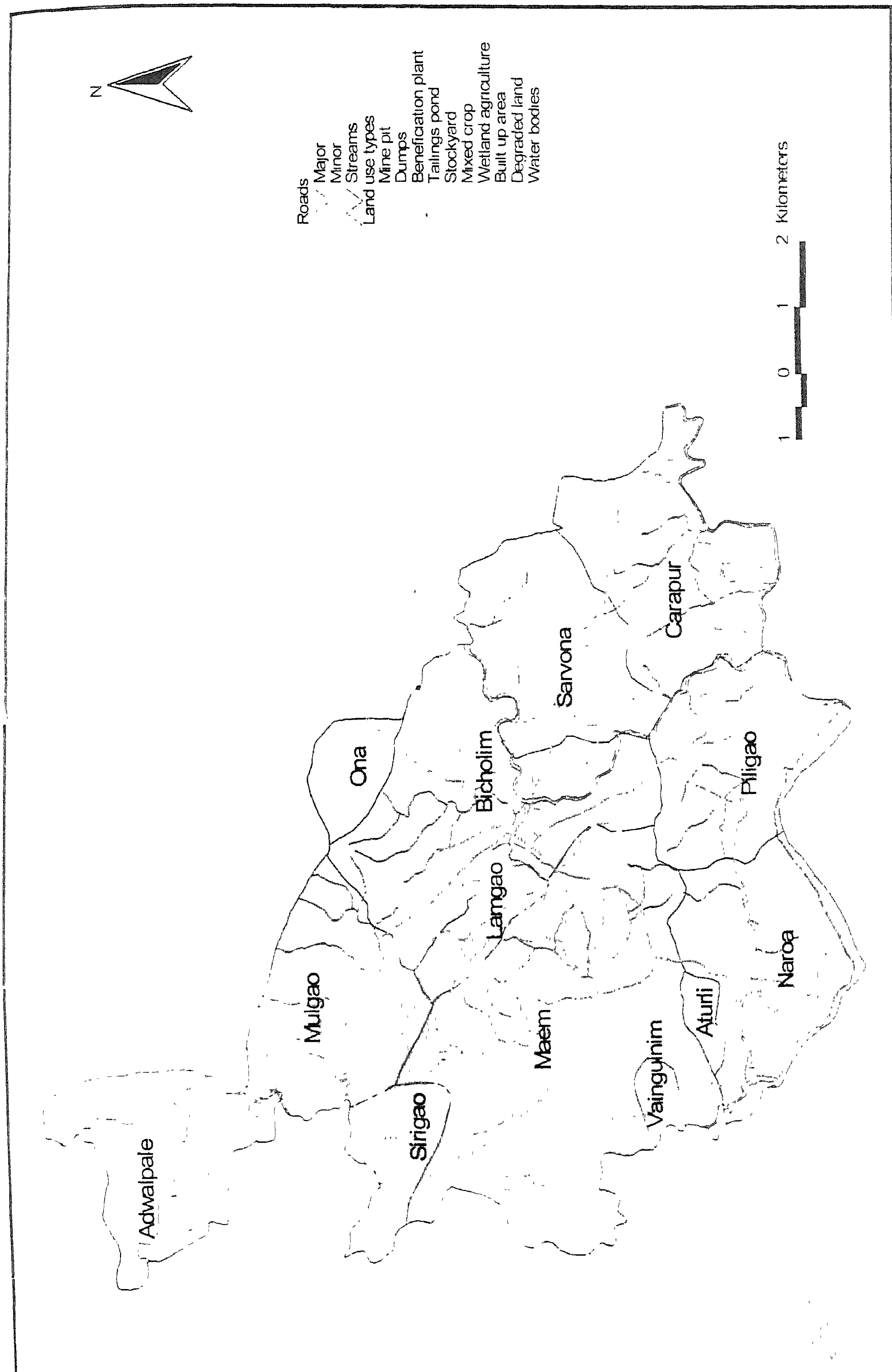


Figure 3. 15 Land use - cluster I

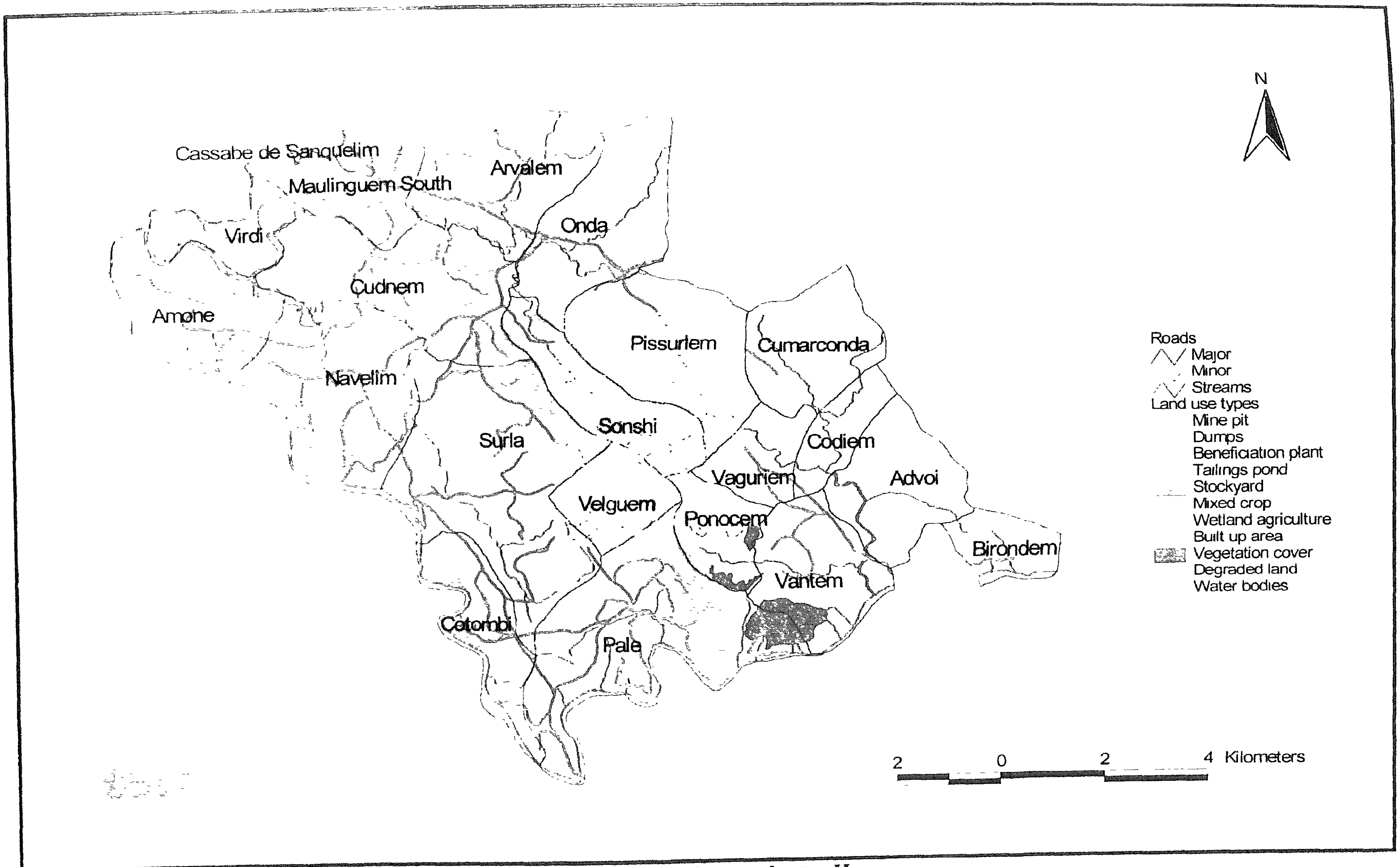


Figure 3. 16 Land use - cluster II

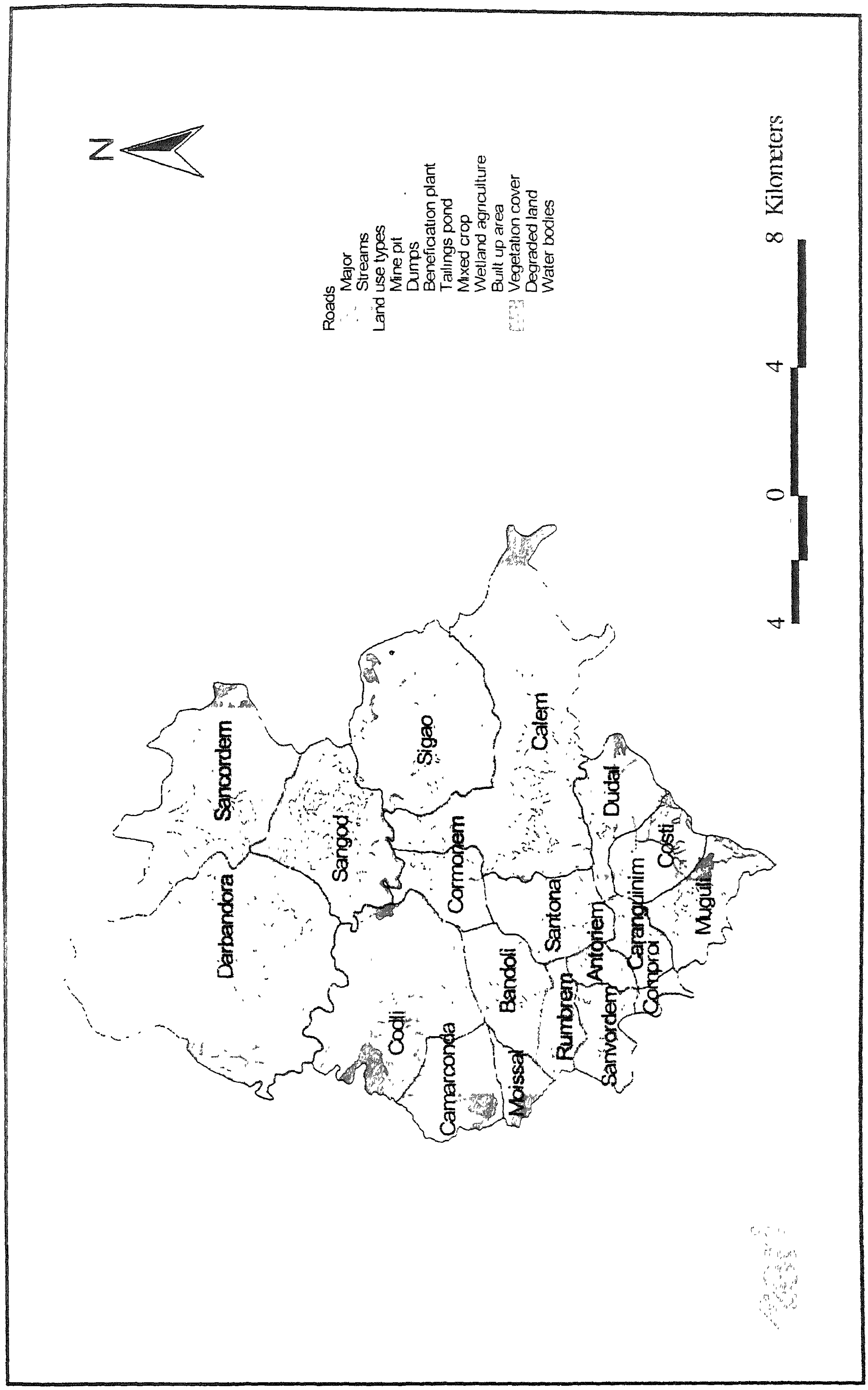


Figure 3. 17 Land use - cluster III

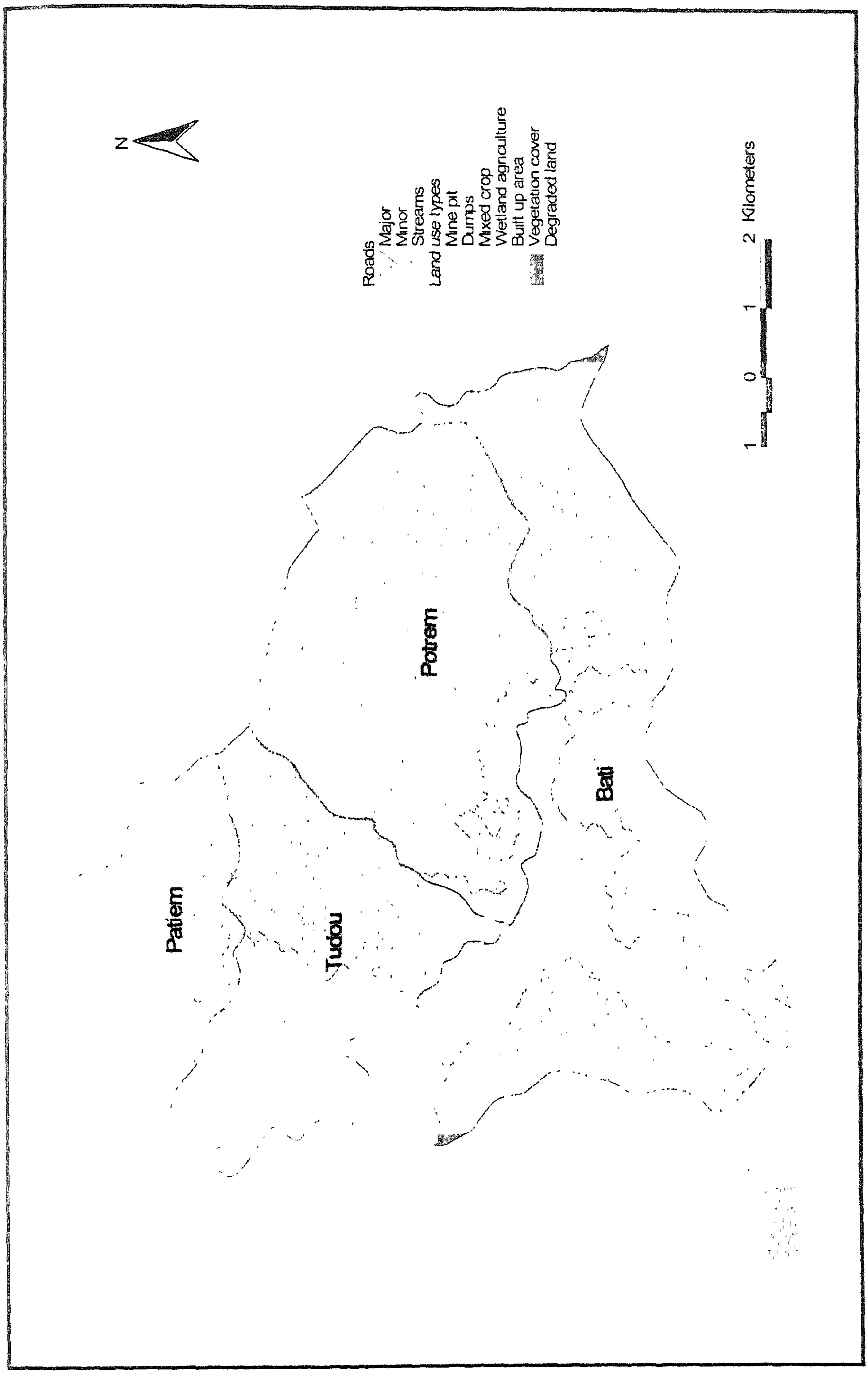


Figure 3.18 Land use - cluster IV

Impact on forest land

Mining districts of Goa are controlled by the Directorate of Industries and Mines. The underground right of mining usually overlaps with the surface rights and, as such mining is required to be done with the consent of the surface-rightholders These surface-rights vest either with the (i) State Government as far as forest and revenue lands are concerned, and (ii) private individuals.

Those mining leases where forest areas are involved have to be submitted to the Forest Department, Government of Goa, for clearance by the Ministry of Environment and Forests, Government of India, as is mandatory under the Forest (Conservation) Act, 1980 So far 22 such cases have been cleared by the Government of India, of which details about 18 mines only have been obtained In addition, information has also been obtained for 8 mines for which permission from the Forest Department is pending The details are presented in Table 3 3

Table 3.3. Forest land area affected due to mining operations (hectares)

	Plan	Total for 18 mines	Addl Area for 8 mines	Total 26 mines
1	Total leased area	1443	518	1961
	Forest land	881	364	1245
	Non-forest land	509	112	621
	Private land	53	42	95
2	Area broken up	323	71	394
	Forest land	229	66	295
	Non forest	72	4	76
	Private	22	1	23
3	Area needed for fresh breaking up	202	49	251
	Forest land	176	37	213
	Non-forest	26	4	30
	Private	-	8	8

It is observed that out of 1,245 ha of forest land involved in 26 mining leases, about 508 ha would be affected by mining operations (See Photo 1 and 2)

An indication of the change in vegetative cover during the period 1988-97 as observed in aerial photographs (1988) and satellite imagery (1997) is presented in Table 3 4 The total vegetation cover lost is to the tune of 2,528 ha during the above period through this may not all be due to mining operations.

Table 3.4. Change in vegetative cover

Year	Vegetative cover (hectares)			
	Cluster I	Cluster II	Cluster III	Cluster IV
1988	365	705	10,918	6,247
1997	-	298	9,836	5,573
Difference	365	407	1,082	674
Total vegetative cover lost				2528

Based on aerial photographs of 1960 and toposheets of 1960, the natural green cover in private areas in all the taluka of the state was of the order of 38,733 ha. As per the latest land use statistics, private forests in the state presently constitute 20,000 ha, only thereby indicating a loss of 18,733 ha over a period of 37 years Again this may not be all through mining activity.

Impact on land and soil quality

Nature of dump material

Since the ore to overburden ratio in the mining belt of Goa ranges from 1:2 to 1:3, an enormous amount of waste material is generated per tonne of iron ore produced. Back filling of the mined out land progressively is not being practiced largely (Pale mine of Chowgule is back filling only a part of the excavated mine) due to reasons mentioned elsewhere. As such, waste materials are piled up in the form of heaps. Since adequate land is not available for proper dumping, the dumps are typically steep and high They are usually as high as 30 m but at times upto 50 m and slopes are usually at the normal angle of rest of the material - about 30° (See Photo 3). Due to paucity of dumping area, in many mines dumping is done outside the leasehold area. The mining belt of Goa is dotted with such dumps

The dumps are generally categorized as dead dump and active dumps Dead dumps are old dumps where no further dumping is being done. These dumps may consist of overburden material, reject ore, subgrade ore, or a mix of all these and tailings from beneficiation plants. Active dumps are running dumps where dumping of all these types of material is continuing. In addition to overburden material, subgrade ore, i.e., ore not conforming to marketable standards (generally Fe content 55 to 58%) and reject ore (Fe content less than 55%) are also dumped separately in some mines to cater to future demand when there is market for such type of ore. Sometimes subgrade ore is mixed with good quality ore and marketed. The subgrade and reject dumps, as such, are usually not rehabilitated permanently except for taking measures to guard against possible slipping/slumping, etc. although erosion of material through wind and water action occurs. The stock pile dump at the barge loading points are purely temporary and remain until loaded without any treatment against loss of material from them.

A few dump samples analyzed reveal that the materials differ in composition depending upon the succession of dumping followed. However, they do not appear to differ from one another very widely but fall within a narrow range of variation. The waste materials dumped are, in general, deficient in essential elements like nitrogen, phosphorous and potassium as also calcium and magnesium, but rich in silica, alumina and iron. They are highly deficient in organic carbon which is almost close to absent The pH of the materials is near neutral to slightly acidic High acidity has not been encountered in any area Available phosphorus and potassium are far below the desired level. The mechanical analyses of the less than 2 0 mm fraction of the material show that silt + clay generally form a low percentage (around 4.0%) in some dumps whereas the fine and coarse sand together from the bulk of the material. However, presence of clay band in some of the sites increase the percentage of fine fraction (30 0 - 67.0%).

The rock wastes, where particles are solid and above 10 mm diameter can hold very little water because the spaces between the particles are too large to hold water by capillarity Materials with particle size below 10 mm hold water to some extent, but good water storage is not possible until the particle size is below 0.2 mm The effectiveness of water storage is relative to the distribution of rain through the year In Goa 2700-3500 mm of rain fall in about 110 days in a year leaving about two-third of the year comparatively dry This results in considerable drought condition in the dumps for greater part of the year. The surface of the dumps tend to be rather different from lower down and may dry out completely during a dry spell However, considerable amount of water may be stored in the body of the dumps. So there may be a problem of surface drought to be overcome. If a plant can only get established and develop adequate roots it will be able to tap the water lower down without difficulty

The dumps of these coarse materials always have some percentage of fine materials The fine materials tend to get washed down during rainfall to lower parts of the dumps, leaving the upper layers extremely open and porous. The accumulation of fine material lower down allows adequate water storage Here again, deep-rooted plants are likely to prove better against surface drought.

Heat received by plants is lost either by convection as air moves over the leaves, or by evaporation from leaves resulting in lowering down the temperature Bare dumps without any vegetation behave very differently Incidence of tropical sun in this region being direct there is greater absorption by the body of the dumps, convection is much more difficult since there is only one continuous surface over which air can move, and after the initial loss of water there is no evaporative cooling. As a result, the temperature of these laterite and ferruginous heap surfaces rise considerably. Plants growing sparsely under such conditions may tend to lose water so rapidly that they cannot maintain water balance and die; they may also directly be damaged by the heat. The temperature being highest at the soil surface, plant is affected at this point and collapses, which is known as heat girdling.

The dump materials are usually devoid of nitrogen especially. As nearly all nitrogen in soil originates from the atmosphere, so materials from below ground are not likely to contain

any. The analysis of several dump samples carried out during the study corroborate this. As adequate supply of nitrogen is crucial for plant growth, this factor is probably the most critical in preventing or making establishment of vegetation on such material somewhat difficult, at least until natural nitrogen-fixing processes become operative. Many other plant nutrients are also highly deficient in such materials, particularly, phosphorus, since this is usually scarce or locked up in unweathered materials. Potassium also is quite deficient. It is likely that some of the micro-nutrients may be lacking. The labile pool related to the ion exchange capacity (a property associated with clay-humus complex) or any long-term storage of nutrients are not expected to exist in these raw waste materials which may at best be considered almost similar to skeletal soil. As such, there would be a tendency of any soluble nutrient added to such material and which are not immediately taken up by plants, to get leached away to lower layers out of reach of most plants. It will, therefore, be advisable to add nutrients in small amounts at frequent intervals until sufficient organic matter accumulates to act as a pool, which may not be earlier than a few years. The problems of acidity, presence of toxic materials or saline-sodicity have not been encountered in any of the mines or dump sites.

The average results of the analyses of the dump samples indicate that the dump material is far from being a hospitable substrate for most of the plants, and there has to be considerable input in the form of ameliorative substances to bring it to the level when plants will establish easily and put up reasonably good growth. Because of open texture, the materials have poor retentive capacity for moisture as well as nutrients.

The dumps, do not provide suitable substrate for vegetation and are, usually, susceptible to slumps, slides and erosion (See Photo 4) during rains, especially in heavy monsoon. Several constituents of the dump material go down the slopes to lower valleys and plains, either in mechanical suspension or in solution to affect the depositional areas in various ways. In order to get an idea about such translocation and deposition, samples from three different points along a transect running from the dump to agricultural field at Onda mine of Chowgule were taken by TERI team and analyzed for a few relevant parameters. This may be taken as the crest, toe and foot of the dump. The results show very little translocation of mechanical separates down the slope gradient. pH value did not show any significant change and were near neutral in all the three positions (around pH 6.0), but constituents like N, P, K, Mg and Na showed some enrichment down the gradient. Significantly higher levels of organic carbon were observed at the toe and foot positions as compared to the crest sample. However, no definite trend could be established because the dump is active and recent, and has not undergone the onslaught of rains much. Similarly available P and K also showed marked translocation into the two lower positions with values 2.02 and 2.07 ppm in respect of P and 44.70 and 75.85 ppm in respect of K. pH values are near neutral indicating no apparent acidic discharges from the mine site. The nutrient levels are not that low to affect normal agriculture. In Cudnem nalah command area, the texture of soil has become coarser than the soils of adjoining and unaffected areas. Clay contents are very low, but organic carbon levels are fairly high. This may have some untoward effect on the

retention and availability of moisture to growing crops. The results of soil samples taken from eight locations are given in Annexure 3.3

IBM carried out a study of 9 samples within 0.6-1 0 m of silt deposited in agricultural fields situated downslope of some mine dumps. It was found that the deposits of so-called silt (which actually is a mixture of clay and silt together with some fine sand) in these agricultural fields or villages Nawarwada, Gawethone, Surla and Pissurlem contained 10.2 to as high as 40 4% of clay with cation exchange capacity in the range of 7-15 m.e./100 g (Annexure 3 6) Such materials normally improve the texture of the soil and enhance the moisture and nutrient holding capacity. However, the thick deposit, instead of betterment, usually acts as a blanket over the existing productive soil in these cases

Surface soil quality around mine areas

The surface soils around the mining areas is highly disturbed and unfertile mostly with very little vegetation. Apparently, these lands have been very much biotically interfered with. Down the slope at the foot hill some agricultural fields occur at the concave landforms or valleys which are mostly cultivated for paddy. As per IBM estimate they have maximum values for Ca, Mg, P and K of the order of 0.95, 2.02, 0.59 and 1 77 per cent respectively. The levels of these macro-nutrients, as such, are somewhat on the lower side for good cropping. Some physico-chemical properties of soil samples collected from eleven locations and forest area, and undisturbed area (supposed to be virgin land) in Bicholim taluka for a study of MoEF to assess the effect of mining on microbial ecology indicate that they differ from one another considerably (Annexure 3 4). The soils of the agricultural fields are generally near neutral to slightly acidic with low levels of organic carbon (0 01-0.07%), nitrogen (48.7-90 3 mg/g) and phosphorus (0 05-0 8 kg/acre). The forest soil, however, is neutral in reaction, well supplied with organic carbon (0.7%), nitrogen (91.4 mg/g) and fairly good in phosphorus content (0 9 kg/acre) The manganese levels in some of the agricultural soils is somewhat high and so also iron, which can be attributed to ferro-manganic compounds still retained in high amount and not leached away The undisturbed soil is somewhat acidic and with moderate levels of organic carbon and nitrogen The moisture content of most of the soils is moderate to high which may be due to high proportion of finer mechanical separates, the status of which was not reported. Thus, it may be seen that as compared to the forest soils, which although is not without any biotic interference, the soils of the mining belt have 10-15th part of organic carbon generally which has obvious repercussion on productivity. The study indicated a gradual increase in organic matter content with distance from the mine dumps. Organic matter is heavily responsible for moisture and nutrient retention, and physical properties like infiltration, moisture movement, structural development, etc. It plays a vital role in reducing erodibility of the soil also.

The soils of agricultural land, on the contrary, manifest quite different mechanical as also physico-chemical properties. Annexures 3.5 to 3.8 indicate the physical and chemical characteristics of soils in agricultural lands in and around mining areas. Generalization of

analyses of soil samples from about 25 locations in these villages of the mining belt indicate much higher percentage of finer fraction in the soils under agriculture (25.0-75.0%) as compared to the materials of the mine dumps. It was observed that as distance from the dump site increases down gradient, finer fraction increases gradually. However, there is no definite trends as quite a few factors, in the form of variables, come into play, such as topography, relief, continuity of slope, slope gradient etc. It was observed that silt + clay of the upland agricultural field close to the toewall and that of paddy field in the valley at a distance of more than 1 km or so on the same transect varied from 24.0% to as high as 75.0%. This may, in some cases and also to some extent, be attributed to loss of finer material from the higher reaches due to water erosion, and enrichment with the same in the valleys downslope, but mostly due to *in situ* soil development in the valley due to better interplay of the pedogenic factors under better moisture regime in warm climatic condition. However, the aforesaid situation can not be generalized, as in several agricultural fields downslope, and especially in the valleys down the slope of an upland dump, appreciable deposits of finer fractions of mechanical separates can easily be discerned forming a distinct layer or layers of periodical sedimentation. This has distinctively been observed in the Cudnem and Advoi nallah common areas described earlier. This type of deposits vary in thickness considerably ranging from a few centimeters to as high as two or two-and-a-half metres. In the extreme cases, the productive layers rich in organic matter and store of other nutrients, are usually, buried under fresh unproductive raw materials.

Impact on agriculture land

Mining has an impact on agriculture, not so much through a movement of agricultural labour to the mining sector for employment, but rather due to the external effects that mining has on agricultural land through siltation of streams that irrigate these croplands and also in certain areas due to silting of the croplands themselves. In addition, certain agricultural lands have been diverted for dumping of waste material. The proximity of the dumps to croplands, water bodies and settlements can be observed in the land use maps of the clusters (figures 3.15 to 3.18).

The most important part of land resource is the biologically active surface layers - the soil. It is this active system that is so easily destroyed or degraded in mining. Often the top soil is removed from the site and disposed of as the underlying strata are bared to obtain access to materials at depth. In the procedures of iron ore mining in Goa, most of the top soil is either buried under huge piles of waste materials or lost in several other ways and is hardly preserved for future restoration purpose. There are several interrelated dereliction problems that are not merely concerned with the restricted hectarage of the direct land itself, but reach beyond in the adjoining areas.

Apart from the mine excavations and waste dumps which take away land from agriculture and other uses, one of the major impacts of mining has been the run off from external dumps during monsoon season which affects agricultural fields and water courses. The impact of mining on agriculture in Goa is observed in (a) the change in the area under cultivation around the

mining areas and (b) the loss in productivity of crop land due to (I) siltation of land from mine waste, and (ii) reduced availability of irrigation water due to the siltation of irrigation channels Paddy fields are typically low-lying. Run off materials from dumps and tailing points blanket the top organic productive soil of the field (See Photo 5 and 6). Silt, which is mainly aluminium silicate and essentially inorganic in nature, covers the humic layer, affects the microbial population and prevents the micro organisms in the soil from fixing nitrogen. If the silt layer is thin, the fields need to be desilted, and organic manures and inorganic fertilizers need to be added to make them productive. These are normally manures from cow dung, goat droppings, etc. and fertilizers with NPK mixtures. If the silt layer is too thick, and cultivation is still carried on, the yields are low despite higher inputs of fertilizers and manures.

The change in area under cultivation has been noted both through satellite imagery as well as through census data A significant factor for the change in land under agriculture is also due to area being taken up for settlement and other purposes associated with mining activity A 1981 survey by the Indian Bureau of Mines revealed that 253 hectares of agricultural land close to reject dumps were affected. Interpretation of the aerial photographs and satellite imagery indicate that an area of about 320 ha of agricultural land near the dumps are affected in some way or the other although the figures for the same given by the Agriculture Department are much on the higher side.

The Zonal Agricultural Officers have very little baseline data on crop productivity of the region, nor there has been continuous and systematic monitoring of the siltation or of the loss in productivity and the reasons thereof The irrigation department too does not have adequate reliable data on these aspects

The two nallahs, Cudnem and Advoi, receive considerable amount of material in suspension and, also, in solution presumably from the mining areas at the higher reaches The command areas of these nallahs get affected adversely both due to flooding during heavy rains and also through irrigation water with materials from extraneous sources A study of some parts of the areas, indicated that siltation is very heavy and the cumulative effect is really a matter of great concern, as productivity of fields are affected In some cases, the deposits have buried the productive surface soil through a layer ranging from a few centimeters to more than 1 5 to 2 0 metres. Some of the agriculturists who are dependant on these streams had to abandon their cultivation also Exact quantification of the siltation has not been done by any agency of the Goa government.

The agricultural fields in Cudnem village which once used to grow two crops in a year under irrigation, got affected by siltation in two ways - direct wash from the dumps situated at a distance on the eastern side and also through irrigation from the water carrying silt as reported by the villagers. There was observable deposit of silt in variable depth (upto 1 meter) in different portions of the area, depending on topography.

Analysis of the samples (Annexure 3.3) collected from the distributory of Cudnem nallah, an agricultural field in the Cudnem command area where agriculture is still being practiced with

much lower yield as compared to earlier time and an agriculture field in the Cudnem command area abandoned for the last three years, indicate that the surface material has about the same composition indicating the same source of origin. The samples have high proportion of fine sand (80.5 to 85.8%) but silt and clay are in low proportion (4.3-13.2 and 1.1-4.8%, respectively). The samples are near neutral (pH 6.35-6.64), medium in N (0.61-0.69%), P (0.141-0.247%) and K (0.635-0.081%). Organic carbon level is moderate. The high percentage of fine sand gives an indication that the nallah as also the command area received very high quantity of this material as a result of fast moving water down dump slopes which did not allow even fine sand to settle down. The dumps of Sesa Goa, Salgaocar and Keni mines are located on the eastern side of this affected area, and although there are lateritic walls in the form of toe walls and also parallel lateritic walls between the mine dumps and the area, the slope gradient appears to offset their effectiveness or, their might have been breaches in them. The thickness of fine sand in the abandoned field was about 1.0 - 1.5 m. The situation with Advoi nallah and the surrounding agricultural fields are not much different. Samples from two sites in this area indicates that deposition in the area is variable with topography of the fields and range from a few centimeters to about 2.5 meters. The samples substantiate again the same source of origin.

The agriculturists, in such situations, have the option of dredging and removing the deposit, which is a costly proposition. Moreover, once removed, there is no surety of the situation not being repeated. More often than not, the cultivators continue taking crops under the trend of diminishing return, but when it attains a formidable situation, they abandon the practice. Apart from siltation as a regular feature through either washed material from upgradient, flash flow of heavy amount of such materials into agricultural fields were also encountered, which occurred due to sudden breach of arresters during heavy rainfall. There are several agricultural fields very badly affected in this way in many locations (See Photo 6). A typical case encountered was about 8 acres of excellent agricultural land at Abador, Satari, where more than 2.5 m of washed material from minedump upgradient got deposited in a flash flow due to breach of retention wall as reported by the owner. On drying such materials, as was observed, developed wide and deep cracks which put the plant roots under sheer and damaged them.

The adverse effects of such inflow are blanketing the productive surface with unproductive raw materials of fine mechanical separates creating inhospitable soil-water-plant relationship and also inhibiting nutritional cycling and balance. Whatever level of nutrients may be present in the soil may not be available to the crops for their growth and development. In the study area a wide spectrum of the aforesaid situations could be observed, the description of them all seems redundant and purposeless. In summary, soil quality is generally adversely affected and in several instances traditional crop production either becomes uneconomical or impossible. Such lands, affected in various degrees, is to the tune of 320 ha spread over various locations of the mining belt.

Agriculture in several areas is practiced through irrigation by water discharged from sedimentation ponds or tailing ponds and also by pumped out mine pit water. These waters are

invariably reddish in colour due to soluble iron compounds mostly. However, if such water is discharged for the purpose, before the silt and clay fractions are settled, may also affect the agricultural fields progressively with sediment deposits and may have similar adverse effects as described earlier.

Although such silt and clay deposits, especially when they are in excessive amount to blanket the fields to the extent that productive layers with clay-humus complex, attains much lower level for the roots to take their advantage, the effect becomes adverse and deleterious However, if the deposit is thin the damage may not be perceptible and, on the contrary, in some coarse textured soils may help improve the moisture and nutrient retention properties also by improving the texture. This situation may be true for upland agricultural areas especially

Compensation to farmers for loss of agricultural output

The damage to the agricultural field in the mining clusters is extensive and this is also evident from the annual compensation payments made by the companies to farmers for the removal of silt from their land and for loss of production. A rough indication of the magnitude of such payments is obtained form the fact that for one mining company, such compensations account for 15% of the total budget for environmental management.

Compensation is an issue that has been given very little attention by appropriate authorities. While it is a phenomenon that is occurring on a regular basis, there is little regulatory control over it. Compensation is paid only when the cultivator makes a representation to the mining company. The amount of compensation is then determined based on an assessment done by a certified agricultural assessor. Payments are at times made without any such assessment also, purely arbitrarily Field visits indicate that in some areas crop yield has been reduced by about 50%. Lack of baseline information on crop productivity has a dual negative effect On the one hand, the mining company has no basis to ascertain what the farmer says was his original produce is correct; secondly the cultivator has no back up from the authorities in the event of a disagreement with mining company/assessor.

Moreover, a secondary impact which has been reported by the locals, mining companies and the government officials is a change in the attitude of the cultivators, who have found that receiving compensation is a more rewarding proposition than actual cultivation There are instances of cultivators leaving their crop land untilled, but claiming compensation on grounds that the land is now infertile The issue of whether there is a genuine case of lost productivity or whether the cultivator is just choosing the soft option is difficult to ascertain, since there is no baseline established for agricultural production and productivity in the region. It is therefore necessary that such baseline studies be put in place immediately to ensure that if damage does occur, compensation is paid; and that such compensation arrangements are institutionalized to the extent possible to avoid free riders on both sides.

Land rehabilitation

Dump management

An impetus for the environmental awareness for the mining belt came only a few years ago as a result of pressure on the State by the people of Goa especially the villagers. As a consequence, rehabilitation of the dead dumps have become an integral part of mining activity. This is mostly being done through some bio-engineering measures. Control of erosion is given importance in the rehabilitation programme. To make the dumps hydrologically compatible, terraces are made at intervals of 10-12 meters of about 8-10 meters width. Terraced landform with short steep slopes (angle of repose) and gently sloping terraces are stable and less obtrusive. The terrace are generally sloping inward to allow rain water to concentrate at the centre and infilter instead of running down the slope. In addition, efforts are made to establish an adequate cover of vegetation to stabilize the dump slopes and prevent or control erosion.

Until an adequate cover of vegetation has been established, it becomes imperative to make provision to control erosion from these disturbed sites. This is normally achieved by covering the sloping sides of the dumps with laterite boulders of assorted sizes thereby splashing of particles by rainfall and their dislodgement are avoided. In addition, a laterite wall of sufficient thickness (about 3 meters) and height (2.5-3 meters) forms a girdle around the base of dump to arrest water flowing down the slope. Often a trench, about 1.5-2 meters deep and about the same in width, runs parallel to the girdle, a few meters away, and a second retention wall of laterite blocks is built several meters away. In some of the mine areas, a bed of laterite pebbles of a few meters precede the trench and the second wall. These are meant to filter the suspended material to the extent possible and then let the water flow out of the area into a channel, rivulet or river in a regulated manner.

The runoff and erosion control measures, as indicated earlier, are being adopted in most of the mines. In addition, efforts to clothe the dumps adequately with vegetation have been taken up in the recent years. However, the seriousness attached to vegetating the dumps differ with the mining companies and also the resources canalized for the purpose. Since the substrate available for vegetating is no-soil, with paucity of plant nutrients, suitable aggregation and is often quite inhospitable for plants to establish the task of vegetating has not been quite easy.

Until early 1980s, there had not been much consideration for proper dumping of overburden and protection thereof. These used to be dumped within the mining lease area or on areas outside mining lease procured by the mine owners, but rarely protective measures used to be undertaken. Presently many of the mine owners have resorted to long-term remedial measures such as physical obstruction to the movement of silt by making laterite toe walls, and planting of dead dumps with suitable plants. Environmental regulations require that mined out areas and inactive or 'dead' dumps be rehabilitated. In Goa, as in the rest of India, the favoured form of rehabilitation has been revegetation. Vegetating dumps and old tailing ponds are ensured a green cover and so complies with the regulations. The idea of converting these overburden dumps or mining pits into something of value has been rare. What has been observed in Goa through

detailed visits to mines in the four clusters is that in general, there has been just a normal compliance to regulations with not much attention to converting these into assets. Moreover, not much of scientific approach to the problem was also made with regard to physical checking of run off and erosion or choice of species, etc While cashew dominated the choice of species planted in the first phase of revegetation of dumps from 1983-87, *Acacia auriculiformis* came to dominate this choice over the period since then, with Casuarina remaining the favoured second best Very clearly, there has been a shift towards faster growing trees.

Afforestation efforts by forest department

The forest department had undertaken afforestation on dead dumps in a limited way in Balcornem, Tatodi, Surla, Sigao, and Bambol areas *Acacia auriculiformis* was mostly used with spacement of 3 m x 3 m in 0.3 m^3 pits. No fertilizer was applied and no watering done. The plants are doing quite well with average height of the stand 12 metres and dbh 15 cm.

According to forest department, *Acacia auriculiformis* in the most suitable species for these dead dumps Not only it establishes itself in these inhospitable conditions, it also invades such similar areas in the neighbourhood besides regenerating in the area where it is planted Moreover, the rate of growth is satisfactory and it acts as a catalyst in the process of succession The species of secondary succession occurring in the area are: *Dalbergia paniculata, Alstonia scholaris, Woodfordia floribudna, Macaranga paltata, Trema orientalis, Clerodendron spp*, *Eupatorium spp* and *Grasses*.

Afforestation by mine owners

A total of 710 ha of mined land/dumps has been planted till 1996 with different species Extensive plantations of *Acacia aurculiformis, Casuarina equisatifolia*, and cashew have been carried out in the dumps and surrounding areas Quite a few mining companies have reported the growth of these species as satisfactory. *Acacia auriculiformis* attained a height of 10 metres and a dbh of about 10 cm in 5-6 years. *Casuarina* attained a height of 11 meters in 10-12 years Cashew plantation attained an average crown width of 5m in 8 years and the plants started yielding fruits after 5 years. *Acacia mangium* is a strong light demander having deep root system and the loose materials of dumps appear to be quite suitable for its growth. The species has been introduced in this area by M/s Sesa Goa in a limited scale. Few isolated trees were found to have attained a height of 15 metres and a diameter of 30 cm in 8 years in Sankheli mines and on the roadside near Codli mines. However, it may catch up fast.

The plantation procedure generally being followed is making the pits of 0.3 m^3 at 3m x 3m spacing ready before the onset of rains with about 100g of mixed fertilizer and planting with the onset of monsoon. Application of mixed fertilizer is repeated in the first two years. Rehabilitation of waste dumps have gained considerable importance over the years and, by and large, most of the companies are enlarging their afforestation activities by opening an environmental cell. Sesa Goa and Dempo have done commendable work so far.

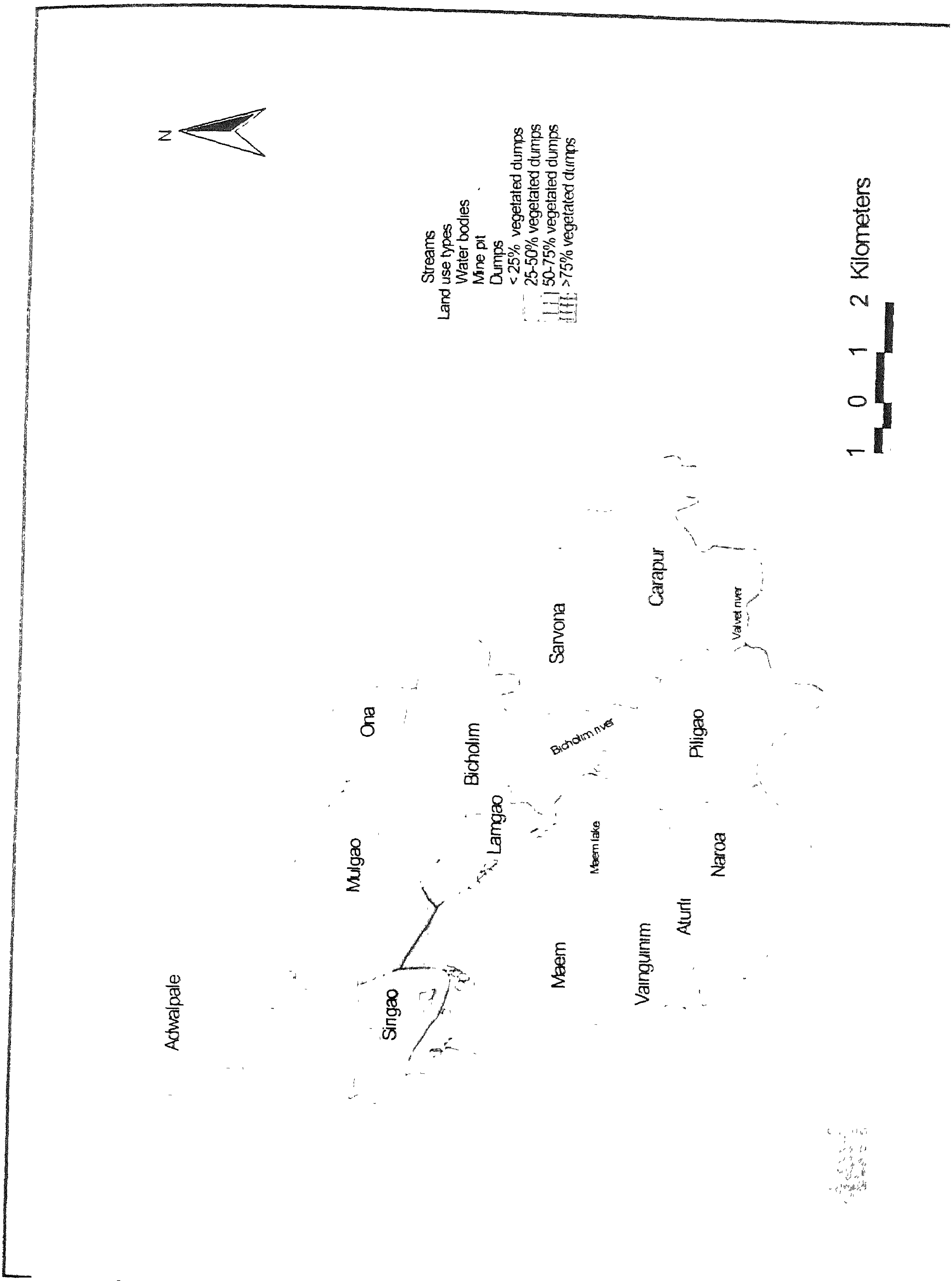
Status of reclamation of dumps

As given in Table 3.2 the total land under all types of dumps (waste and ore dumps) is estimated at 1300 hectares in the study area. If we assume that 15% of the dump area is occupied by ore dumps including sub-grade ore, the waste dumps would cover about 1100 hectares. Reclamation of the waste dumps through plantation/vegetation cover has been taken up by the companies. Actual mine-wise data on the quantum of land reclaimed and vegetated was not available. We have estimated the vegetation cover in the dumps through satellite imageries for each cluster and the details are given in Table 3.5. Figures 3.19 to 3.21 show dump reclamation status in cluster I, II and III, respectively.

Table 3.5. Reclamation (through updation) status of dumps (estimated) (figures in hectares)

Cluster	Total dump area	Estimated ore dump area	Waste dump area	Vegetated/reclaimed area	Balance to be reclaimed
Cluster I	193	29	164	70 (43%)	94
Cluster II	599	90	509	150 (29%)	359
Cluster III	428	64	364	80 (22%)	284
Cluster IV	81	12	69	10 (14%)	59
Total	1301	195	1106	310 (28%)	796

It is observed from the table that about 310 hectares (28%) of waste dumps has been vegetated leaving a balance of about 800 hectares to be reclaimed/vegetated


N
Streams
Land use types
Water bodies
Mine pit
Dumps
< 25% vegetated dumps
25-50% vegetated dumps
50-75% vegetated dumps
>75% vegetated dumps
1 0 1 2 Kilometers
Adwalpale
Singao
Mulgao
Ona
Bicholim
Lamgao
Maem
Maem lake
Bicholim river
Sarvona
Carapur
Valvet river
Piligao
Naroa
Aturli
Vainguinim

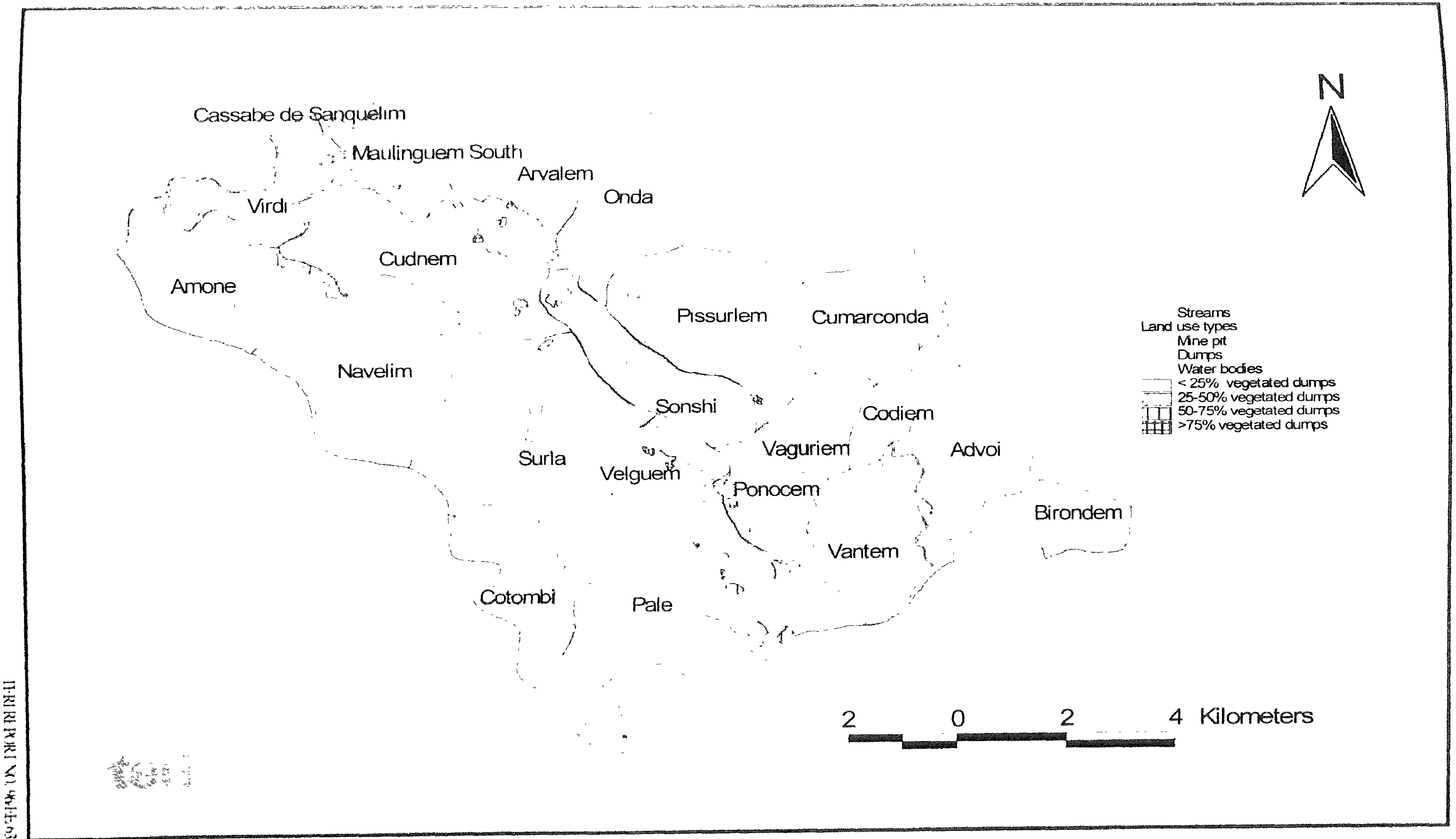
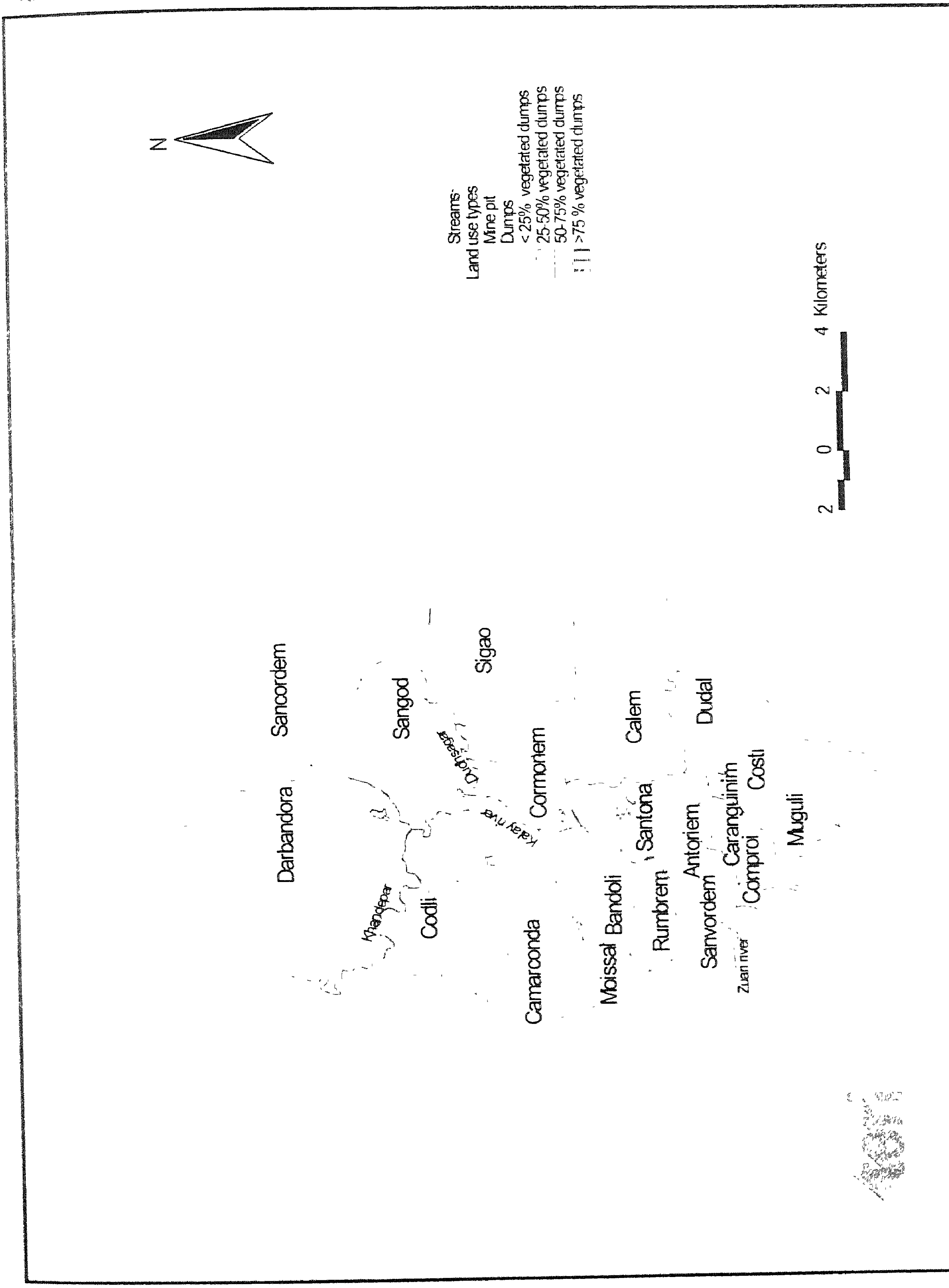


Figure 3. 20 Dump reclamation - cluster II


N
Streams
Land use types
Mine pit
Dumps
< 25% vegetated dumps
25-50% vegetated dumps
50-75% vegetated dumps
>75 % vegetated dumps
2 0 2 4 Kilometers
Sancordem
Darbandora
Sangod
Sigao
Dudhsagar
Cormorem
Kalay river
Khandepar
Codli
Camarconda
Calem
Dudal
Santona
Moissal
Bandoli
Rumbrem
Antoriem
Sanvordem
Caranguinim
Costi
Comproi
Muguli
Zuari river

Status of land rehabilitation efforts

The status of land rehabilitation/afforestation activities carried out in different clusters is briefly discussed below

Cluster I

Since mining in this cluster has been going on for over 40 years, when environmental concerns were not an issue, a number of poor practices are observed.

- Some mines are exhausted and abandoned, with little revegetation
- Many dead dumps are not fully afforested Those which are planted with trees have developed gullies which are left unplanted
- All mines that have been vegetated have planted fast-growing trees like *Acacia, Auriculiformis,* and *Casuarina* Cashews are also growing well in the lateritic soil in some mines

Cluster II

These mines have more of phyllitic clays compared to laterite lumps and lateritic clays The dense location of mines over a small area implies that some mines do not have place to dump rejection near the mines They have to transport rejection 3 to 5 kilometers away form the mine.

- Most mines have planted fast-growing trees like *Acacia, Casuarina* and *Eucalyptus*
- Some mines have planted mixed local trees and they are growing very well
- One mine has utilized pit water to grow fruit trees like banana, coconut, pineapple and medicinal plants. This is a very good practice to save endangered species of medicinal plants and promote biodiversity
- Two mines have successfully planted local forest trees such as Matti, Kindall, Shishum, Ason, Sinarsaton, Shivon, etc
- Two companies have established nurseries and supply tree saplings to their mines Other mines depend for their requirement of tree saplings from government forest nurseries

Cluster III

Most of these mines in this cluster are surrounded by thick forest

- A lot of top soil must have been there but few mines are keeping the top soil separately for future use.
- Some mines have planted fruit trees like Mango, Tamarind, Amla, Cocum, Jackfruit and Cashew Survival and growth is good
- In some mines in this cluster there is siliceous ore Trees that tolerate sandy soils should be planted in these dumps *Casuarina* and *Acacia* could be tried
- One mine has its own nursery. The rest of the mines procure their requirement from forest nurseries. Lack of extension services from government nurseries is a complaint for lack of information regarding the type of tree species available and suitable for dumps.

Cluster IV

Most mines in this cluster are newly opened mines. They are surrounded by thick jungle Dead dumps are few. Revegetation is not significant here. No mine have their own nurseries Tree saplings are brought from forest nurseries.

More generally, the following are some of the poor practices observed in some mines

- Not preparing the soil for plantation or adding garden soil near the planted trees
- Planting tree sapling without cutting and discarding the polybag
- Planting trees without selecting tree species for particular soil. For example, planting teak, jacaranda and raintree on top of a dump without any irrigation.
- Planting trees without fertilizer during planting or end of monsoons
- Pulling the tree seedling from the polypot and planting it naked.
- Loading the fragile tree sapling with polypot into trucks or vans without care and over crowding.
- Total absence of after care; so revegetation stops at the planting stage.
- Transplanting more than a year old *Acacia auriculaformis* saplings from the ground

Air

Ambient air quality standards

Ambient air quality standards prescribed by CPCB (1994) are categorized into three classes industrial, residential and rural and sensitive areas Table 3.6 shows the 24/8 hours concentration limits for suspended particulate matter (SPM), sulphur dioxide (SO_2), oxides of nitrogen (NO_x), respirable particulate matter (RPM), lead (Pb) and carbon monoxide (CO). The concentration of pollutants should be within these prescribed limits 98% of the time

Air quality in the mining villages in the study area

Some mining companies monitor and record ambient air quality data in their respective mining areas Air quality data from these monitoring stations were available for three seasons for 1995-96 and all analysis of air quality is based on these data The available monitoring data for a particular station in a village was taken as representative for the village Since there is no air quality data available for non mining areas, it was not possible to differentiate the contribution of mining to air environment in these areas The 24 hour average concentration of SPM, SO_2 and NO_x for summer, post monsoon and winter seasons for some mining villages/settlements in cluster I, II, III and IV of the study area are given in Table 3 7

Table 3.6. Ambient air quality standards ($\mu g/m^3$)

Pollutants	Industrial area	Residential, rural and other areas	Sensitive areas
Sulphur Dioxide	120	80	30
Oxides of Nitrogen	120	80	30
Suspended particulate matter	500	200	100
Respirable particulate matter	150	100	75
Lead	1.5	1.0	0.75
Carbon Monoxide +	5000	2000	1000

* 24 hourly/8-hr+ value should be met 98% of the time in a year. However 2% of the time it may exceed but not on two consecutive days

Table 3.7. Seasonal variation of air quality for few villages/settlements in clusters (in $\mu g/m^3$)

Village/built up area	Season	SPM	SO_2	NO_x
Cluster I				
Sirigao	Summer	265	19	25
	Post monsoon	208	8	15
	Winter	215	10	15
Onda	Summer	170	8	15
	Post monsoon	125	7	12
	Winter	149	8	10
Piligao	Summer	330	15	32
	Post monsoon	193	3	18
	Winter	183	9	15
Cluster II				
Pissurlem	Summer	330	13	17
	Post monsoon	242	15	21
	Winter	372	14	17
Vovelem	Summer	135	19	43
	Post monsoon	115	21	27
	Winter	105	15	26
Vagona Kuvna nagar	Summer	375	[illegible]	10
	Post monsoon	191	6	12
	Winter	121	8	11
Daucona	Summer	332	5	13
	Post monsoon	159	10	15
	Winter	256	6	12
Honda	Summer	170	10	18
	Post monsoon	139	11	23
	Winter	154	13	22

Village/built up area	Season	SPM	SO_2	NO_x
Harvalim	Summer	133	8	14
	Post monsoon	119	9	14
	Winter	122	9	15
Navarwada	Summer	242	8	11
	Post monsoon	177	4	9
	Winter	237	6	5
Cluster III				
Cormonem	Summer	290	12	18
	Post monsoon	209	19	18
	Winter	290	14	23
Sigao	Summer	228	16	21
	Post monsoon	192	5	9
	Winter	180	7	9
Codli	Summer	355	14	25
	Post monsoon	159	5	13
	Winter	256	6	12
Tatodi	Summer	110	8	15
	Post monsoon	88	5	9
	Winter	129	7	10
Molem	Summer	120	10	12
	Post monsoon	89	5	9
	Winter	84	7	9
Cluster IV				
Tudou	Summer	218	12	19
	Post monsoon	160	6	10
	Winter	195	6	19

As can be seen, in many villages SPM levels exceed the permissible standards for residential and rural areas The SPM concentration was found to be higher in summer seasons than winter and post monsoon seasons Heavy precipitation in monsoon season might be the reason for relatively less concentration in post monsoon season SO_2 and NO_X levels are well below residential and rural standards in all the villages The SPM concentration for villages in the study area are also presented in Figures 3 22 to 3 25

Dust levels in operating mines

The SPM concentration levels in almost all the operating mines exceed the CPCB standards prescribed for industrial areas The dust fall rate in mine areas and mining villages is reported to be varying from 8 to 16 t/sq km/month and 2 to 4 t/sq km/month respectively, which in many cases is exceeding the standards prescribed by CPCB (10 t/sq.km). The respirable size fraction in ambient air is reported to be varying from 10 to 14% of suspended particulate matter and free silica content in respirable dust varies from 7 to 12%, which is higher than the guidelines

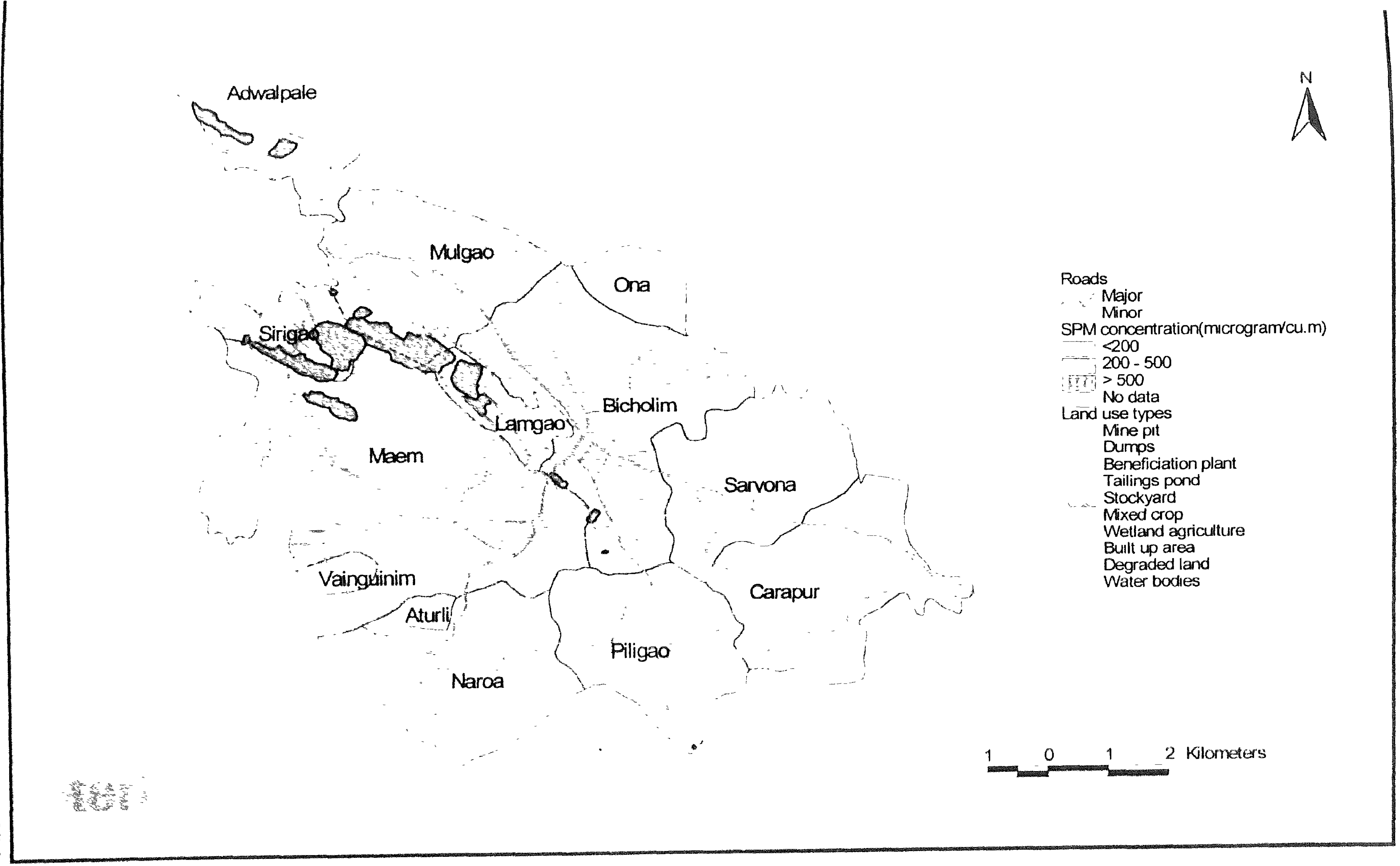


Figure 3. 22 SPM concentration - cluster I

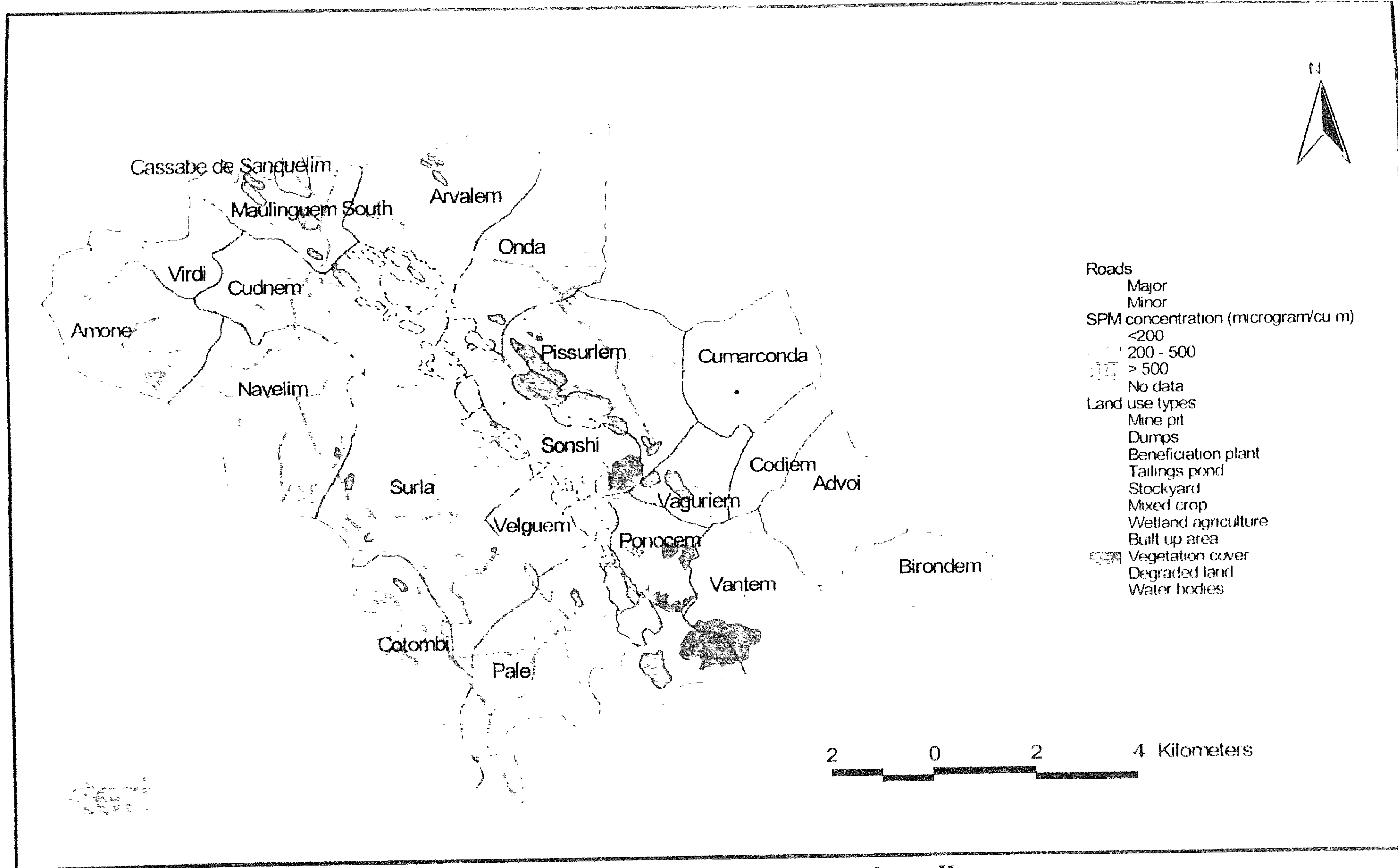


Figure 3. 23 SPM concentration - cluster II

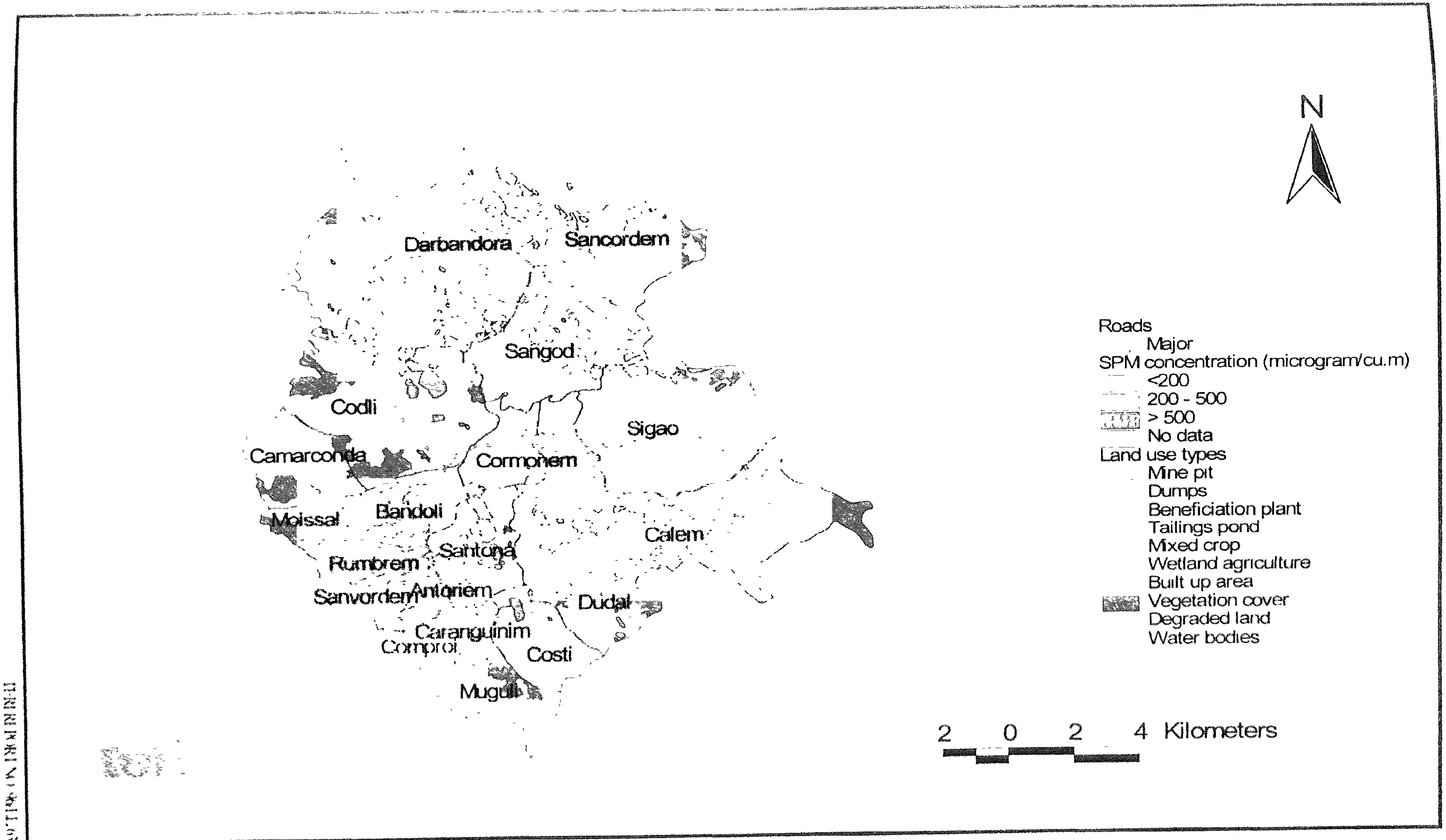


Figure 3.24 SPM concentration - cluster III

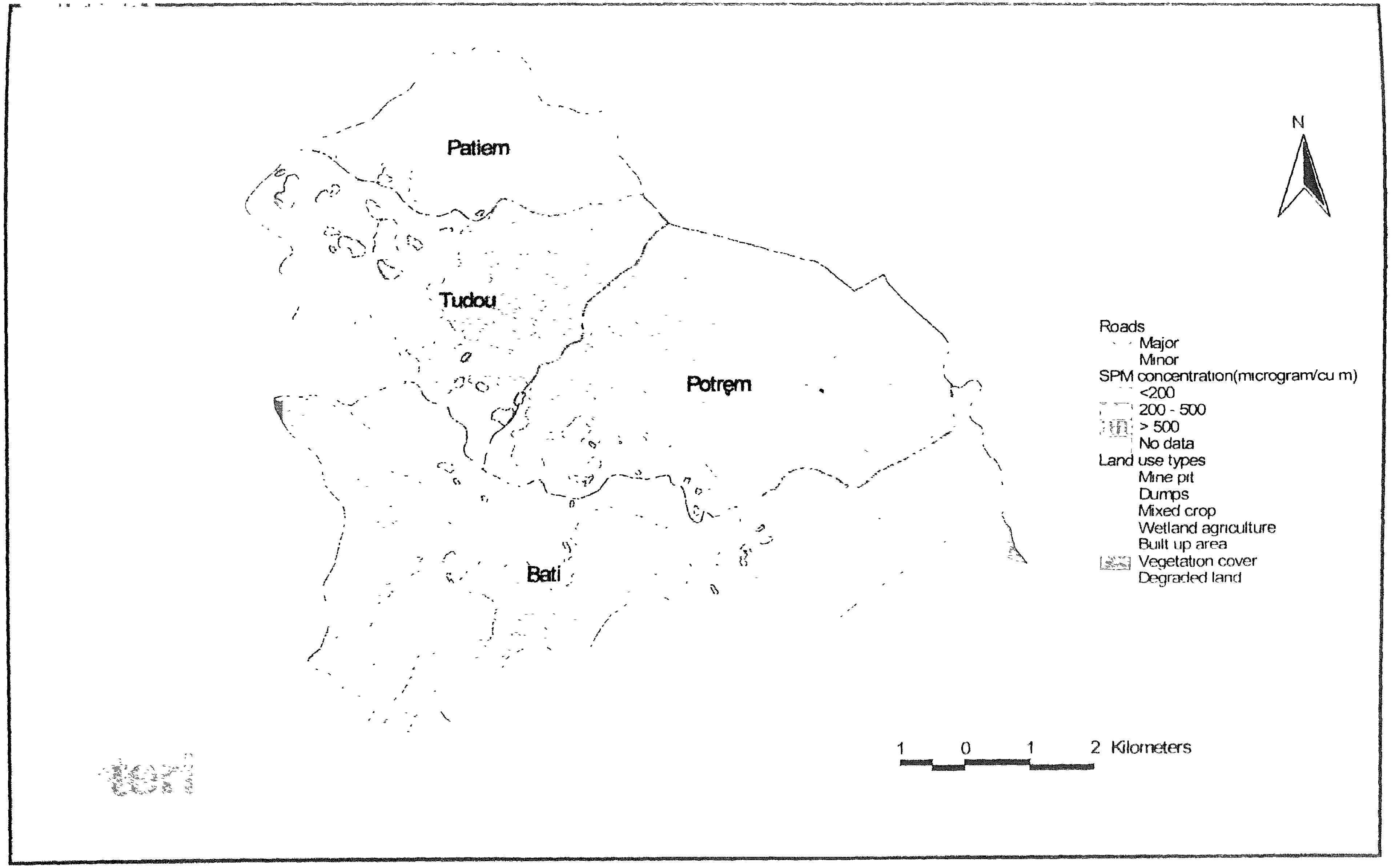


Figure 3.25 SPM concentration - cluster IV

provided (should not exceed 5%) by the Directorate General of Mine Safety

Workers exposure to dust levels

Operators exposure to dust levels are reported to be varying from 0.87 to 5.68 mg/m³. Table 3.8 gives the operators' exposure to mine dust. The standards prescribed by Directorate General of Mines Safety for respirable dust is (3 mg/m³ for 8 hours of working period where free silica content should not exceed 5%). Free silica content in respirable dust is also also reported to be varying from 7-12%. The drill and chute operators are exposed to dust levels higher than the standard.

Table 3.8. Workers exposure to mine dust

Operators	Dust concentration, mg/m³
Shovel operator	0.87-1.46
Drill operator	3.81-5.68
Chute operator	2.81-4.65
Dozer operator	0.90-1.14
Crushing & screening plant operator	1.43

Air quality in selected road corridors

The large quantity of ore transported on mine and public roads have been identified as one of the major source of dust pollution and is resulting in deterioration of ambient air quality in many villages as the truck passes through the settlements before reaching the loading points. Ore spillage due to overloading and over speeding (See Photo 7) is the primary cause of emanation of dust from road. Ore spillage, fugitive dust generation and dust concentration in surrounding air environment have been worked out for various traffic corridors and are given in Table 3.9. The ambient dust concentration in surrounding areas along the road corridors is estimated to be varying from 850 to 1500 µg/m³ in cluster III and 450 to 800 µg/m³ in cluster II and 400 to 650 µg/m³ in cluster I. It exceeds the ambient air quality standards prescribed by Central Pollution Control Board (CPCB) for residential area (200 µg/m³).

Report of the committee constituted by the Government of Goa in 1994 reveals that several patients visiting Curchorem primary health centre suffer from diseases caused as a result of excessive dust pollution. The report also highlights the increasing trend of respiratory and other airborne diseases in the Curchorem area. Although no such reports are available from North Goa, there are public resentments against dust pollution surrounding mines and ore traffic corridors.

Table 3.9. Air quality status in road traffic corridor

Cluster	Loading station	Village	Quantity transported in 1995-96 (Mt)	Trips/yr	Spillage (t/yr)	Fugitive (t/yr)	Fugitive (g/s)	Concentration ug/m³
Cluster I	Sarmanos	Piligao	1 85	1,85,000	925-1850	93-185	4 9-8 2	500-650
	Sirsaim	Adwalpale	0 57	57,000	285-570	29-57	1 5-2 5	300-450
	Kalvi	Sirigao	0 27	27,000	135-270	14-27	0 7-1 2	250-400
Cluster II	Khazan	Cotambi	0 99	99,000	495-990	50-99	2.6-4 4	550-800
	Amone	Amone	0 87	87,000	435-870	44-87	2.3-3.8	350-550
	Cotombi	Cotambi	1 33	1,33,000	665-1330	67-133	3.6-5.9	550-800
	Navelim	Navelim	1 03	1,03,000	515-1030	52-103	2 8-4 5	300-450
	Sinori	Surla	0 86	86,000	430-860	43-86	2.3-3 8	300-450
	Vagus	Cotambi	2 02	2,02,000	1010-2020	101-202	5 3-8 9	550-800
Cluster III	Sanvordem	Sarvordem	2 77	2,77,000	1385-2770	139-277	7 4-12.3	850-1500
	Xelvona	Xelvona	1 31	1,31,000	655-1310	66-131	3 5-5 8	400-500
	Capxem	Panchwadi	1 33	1,33,000	665-1330	67-133	3.6-5 9	400-500

Note:
I) No. of trips is based on a truck capacity of 10 tonnes (design capacity)
ii) Ore spillage is assumed as 0 05 to 0 1% of the quantity transported
iii) Fugitive dust is assumed as 10% of the ore spillage

Estimating air residuals

The sources of emissions affecting air quality in the area are as follows i) fugitive dust from opencast mining operations e.g. movement of heavy earth moving machinery, drilling and blasting etc ii) exhaust from trucks, dumpers, dozers and shovels, iii) during loading and unloading operations, iv) dust generation from waste dumps and ore dumps due to wind erosion, v) fugitive emissions due to movement of trucks and vehicles, and vi) emissions from domestic cookstoves

Dust concentration at the sources from various activities in the mines are presented in Table 3 10 Crushing and screening points are the major sources of dust pollution, besides heavy vehicle movement on haul roads in mines Dust emanates from various sources in the mine, becomes airborne and affects the ambient air quality in and around the mines Ambient air quality is observed to be higher than the industrial standards (500 μg m^{-3}) for mines The control measures being adopted at different dust generating points are also given in Table 3 10 Water spraying is the commonly practiced control measures to reduce dust from loading sites, haulage road and crushing points Dust extractors are used in some cases to collect dust emanating from drilling machine Since the control measures are not being taken in many dust generating sources or are not so effective to abate dust at the source, the dust concentration levels are estimated at a higher level Effective measures need to be taken by the mining companies to mitigate dust pollution Plantation on dumps and green belts surrounding mines and dumps would considerably reduce the dust generation and its dispersion In the road corridors, the condition of roads need improvement and some roads have to be widened

Air quality index

An air quality index (AQI) for each village in clusters I, II, III and IV has been estimated This is based on AQI formula developed by Oak Ridge National Laboratory (ORNL), USA as given below

$$ORAQI = \left[39.02 \sum_{i=1}^{3} (X_i/X_s)\right]^{0.967}$$

ORAQI Oak Ridge Air Quality Index

X_i environmental parameters (SPM, SO2 and NOx)

X_s environmental standards (considered CPCB standards)

AQI has been developed using three parameters viz SPM, SO_2 and NO_x average concentration levels for villages The village-wise average concentration levels are given in Table 3 11

Table 3.10. Dust concentration at the source

Sources	Activities	Concentration Ranges, $\mu g/m^3$	Existing control system	Comments
Loading site	Mechanical activities and wind erosion	799-2214	Water spraying at muck piles	Handling of fine ores causes dust
Dumping point	Mechanical activities and wind erosion	450-1300	Nil	Wind erosion raises fine particulates
Haulage road	Heavy vehicular traffic	900-2080	Water spraying, plantation along the side of the haul roads	Road compaction plays an important role to reduce dust
Crushing point	Crusher	1955-4295	Water spraying	Needs better spraying system
Screening plant	Screen and vibrator	644-1431	Water spraying	Needs better spraying system
Drilling site	Drill bit rotation	989-2215	Dust extractor, in some cases wet drilling	Many mines have eliminated drilling
Blasting point	Blasting	572-899	Nil	Many mines have eliminated blasting
Benches	Movement of mining machinery	682-2315	Nil, sometimes water spraying	Need better gradation
Road side	Road traffic	408-1664	Nil	Poor road condition and high traffic density
Workshop	Movement of mining equipments	420-850	Water spraying	Not paved/covered
Barge loading site	Loader and truck movement	600-1010	Nil	Needs systematic arrangements
Bench face	Excavation/ Loading	500-900	Nil	No control arrangement

Table 3.11. Air quality for villages (in µg/m³)

Villages	SPM	SO_x	NO_2
Cluster I			
Adwalpale	202	15	15
Sirigao	265	19	25
Mulgao	205	12	22
Lamgao	218	16	25
Bicholim	190	11	16
Cluster II			
Arvalem	169	15	19
Cudnem	220	22	27
Surla	260	16	21
Velguem	375	17	24
Pale	331	11	23
Pissurlem	390	15	32
Sonshi	375	15	27
Vaguriem	135	7	15
Onda	170	10	18
Ponocem	190	15	26
Cluster III			
Sigao	228	16	21
Sangod	205	12	20
Cormonem	236	12	18
Codli	355	14	25
Santona	306	17	32
Costi	245	17	26
Sanvordem	292	10	36
Cluster IV			
Tudou	218	14	22
Bati	189	17	24

The monitored results were compared with the CPCB standards to arrive at the AQI. The AQI of 0-19, 20-39, 40-59, 60-79, 80-99 and >100 is considered as excellent, good, fair, poor,

bad and dangerous respectively. The village-wise details of area, population density, air quality index, activities generating pollutants and existing abatement measures are described in Table 3 12. Figures 3.26-3.29 show the AQI for the villages in the study area and Figures 3 30-3 33 show the AQI and population density for all the villages in cluster I, II, III and IV Villages namely Sirigao, Cudnem, Surla, Velguem, Pale, Sanvordem are considered as stressed since more households (population density >300 per sq.km.) are exposed to poor and bad air quality Villages namely Sonshi, Ponocem, Carmonem, Codli, Santona, Costi also reflect poor air quality but less population is exposed Table 3.13 summarizes the air quality status in the mining villages under three categories based on population density and air quality

Table 3.13. Air quality and population density

Category	Villages
1 Population density > 300 with poor/bad air quality	Sirigao, Cudnem, Velguem, Pale, Sanvordem
2 Population density < 300 with poor/bad air quality	Pissurlem, Sonshi, Ponocem, Carmonem, Codli, Santona Costi
3 Population density > 300 and fair air quality	Mulgao, Arvalem, Surla, Honda

Table 3.14. Air quality status

Taluka	Village area/ population density	Quality AQI	SPM concentration population	Activities	Existing abatement measures	Comments
Cluster I						
1	Adwalpale 6.38 sq km 228/sq km	Good (47) 20-39	< 200 1453	Mine pit, ore transport		Less mining and medium P D
2	Sirigao 2.8 sq km 600/sq km	Poor (65) 60-79	200-500 1721	Mine pit/ore & ob transportation, domestic activity	Water spraying plantation	High intensity mining activity, very high P D
3	Mulgao 7.58 sq km 369/sq km	Fair (51) 40-59	200-500 2797	Mine pit, ore and ob dump, ore transportation		Medium mining activity, high P D
4	Maem 21 sq km 347/sq km	Good (36) 20-39	< 200 7308	Mine pit, ore and ob dump	Water spraying, sweeping	Less mining activity, high P D
5	Pamgao	Fair 54 40-59	200-500	Mine pit, ob dump, ore transportation	Water spraying, sweeping	Medium mining activity
6	Bicholim	Fair 47 40-59	200			Very less mining activity
Cluster II						
1	Arvalem [illegible] sq km 362.35 sq km	Fair 40-59	200 2590	Mine pit, ore transport, domestic activity	Water spraying	Less mining activity & high population density
2	Cudnem 9.91 sq km 303.89 sq km	Poor 60-79	200-500 3012	Mine pit, ob dump, ore transport, domestic activity	Water spraying & plantation	Intensive mining & high population density

Taluka	Village/area/ population density	Quality AQI	SPM concentration/ population	Activities	Existing abatement measures	Comments
3	Surla 16 94 sq km 300 89/sq km	Fair 40-59	200-500 5096	Mine pit ob dump, ore & public transport	Water spraying, plantation, road cleaning	Heavy traffic movements, poor road condition, mining activity, medium population density, uncovered truck
4	Velguem 3 24 sq km 782 14/sq km	Bad 80-99	200-500 2536	Mine pit, ob & ore dump, ore & public transport, built up area	Water spraying, plantation, road cleaning	Intensive mining, high population density, poor road condition
5	Pale 13 54 sq km 476 88/sq km	Poor 60-79	200-500 6457	Mine pit, ob & ore dump, ore & public transport, workshop	Water spraying & plantation	Intensive mining, very high population density, poor road condition, uncovered truck
6.	Pissurlem 8 34 sq km 243 21/sq km	Bad 80-99	200-500 2028	Mine pit, ob dump, ore transport, domestic	Water spraying & plantation	Intensive mining, medium population density
7.	Sonshi 4 74 sq km 95 55/sq km	Bad 80-99	200-500 453	Mine pit, ob dump, ore transport, built up area	Water spraying & plantation	Extensive mining, very low population density
8	Vaguriem 3 11 sq km 89.61/sq km	Good 20-39	< 200 279	Domestic, public road	Nil	No mining, very low population density
9	Onda 7 93 sq km 370 53/sq km	Fair 40-59	< 200 2938	Mine pit, ob dump, ore transport, domestic	Water spraying & plantation	Less mining, high population density
10.	Ponocem 2 99 sq km 146 64/sq km	Poor 60-79	200-500 439	Mine pit, ob dump, quarry	Water spraying & plantation	High mining activity, low population density

Taluka	Village area population density	Quality AQI	SPM concentration population	Activities	Existing abatement measures	Comments
Cluster III						
1	Sancordem 21.17 sq km 59/sq km	Fair (56)	200-500 1243	Mining pit, ob dump, ore transport	Water spraying	High intensity mining, very low population density
2	Sigao 30.1 sq km 30/sq km	Fair (58)	200-500 912	Mining pit, ore and ob dump		Very low population density, medium mining activity
3	Sangod 16.03 sq km 53/sq km	Fair (49)	200-500 855	Mine pit, ore transportation		Very low population density, mining activity
4	Cormonem 6.17 sq km 104 sq km	Poor (62)	200-500 642	Mine pit, ore and ob dump		Low population density, medium mining activity
5	Codli 23.99 sq km 140 sq km	Bad [illegible]	200-500 [illegible]	Mine pit, ore and ob dump, ore and ob transportation	Water spraying, plantation	High intensity mining, and low population density, poor road condition, high traffic, uncovered truck
6	Santona 8.92 sq km 102 sq km	Bad 82	200-500 912	Mine pit, ore and ob dump, ore and ob transportation	Water spraying, plantation	High intensity mining activity an low population density, poor road condition, high intensity traffic
7	Darbandora 44.58 sq km 23/sq km	Fair 51	200-500 1023	Mine pit, ore and ob dump, ore and public transport		Medium mining activity, very low population density
8	Dudal 7.69 sq km 67/sq km	Fair 42	< 200 516	Mining pit, ore and ob dump		Very less mining activity

Taluka	Village/area/ population density	Quality AQI	SPM concentration/ population	Activities	Existing abatement measures	Comments
9	Costi 6 86 sq km 132/sq km	Poor 62	200-500 905	Mining pit, ore, ob dump, built up area	Water spraying plantation	Medium mining activity, low population density, exposed dump, ore transportation
10	Sanvordem 5 11 sq km 787/sq km	Poor 74	200-500 4022	Mining, ore transportation, loading operation, public transport, built up area	Water spraying	Less mining activity, very high population density, poor road condition, very high ore traffic movement, ore stackyard, uncovered truck movement
Cluster IV						
1	Tudou 12 96 23/sq km	Fair (56)	200-500 295	Mining ore and ob transportation	Water spraying, plantation	Medium mining activity, very low population density

Note: AQI-Air quality index, PM- Particulate matter, SO_2-Sulphur dioxide, NO_x-Oxides of nitrogen,
Air quality index.- Excellent 1-19, Good 20-39, Fair 40-59, Poor 60-79, Bad 80-99, Dangerous >100
Population density (persons per sq km) Very low <100, Low 101-200, Medium 201-300, High 301-400, Very high >400

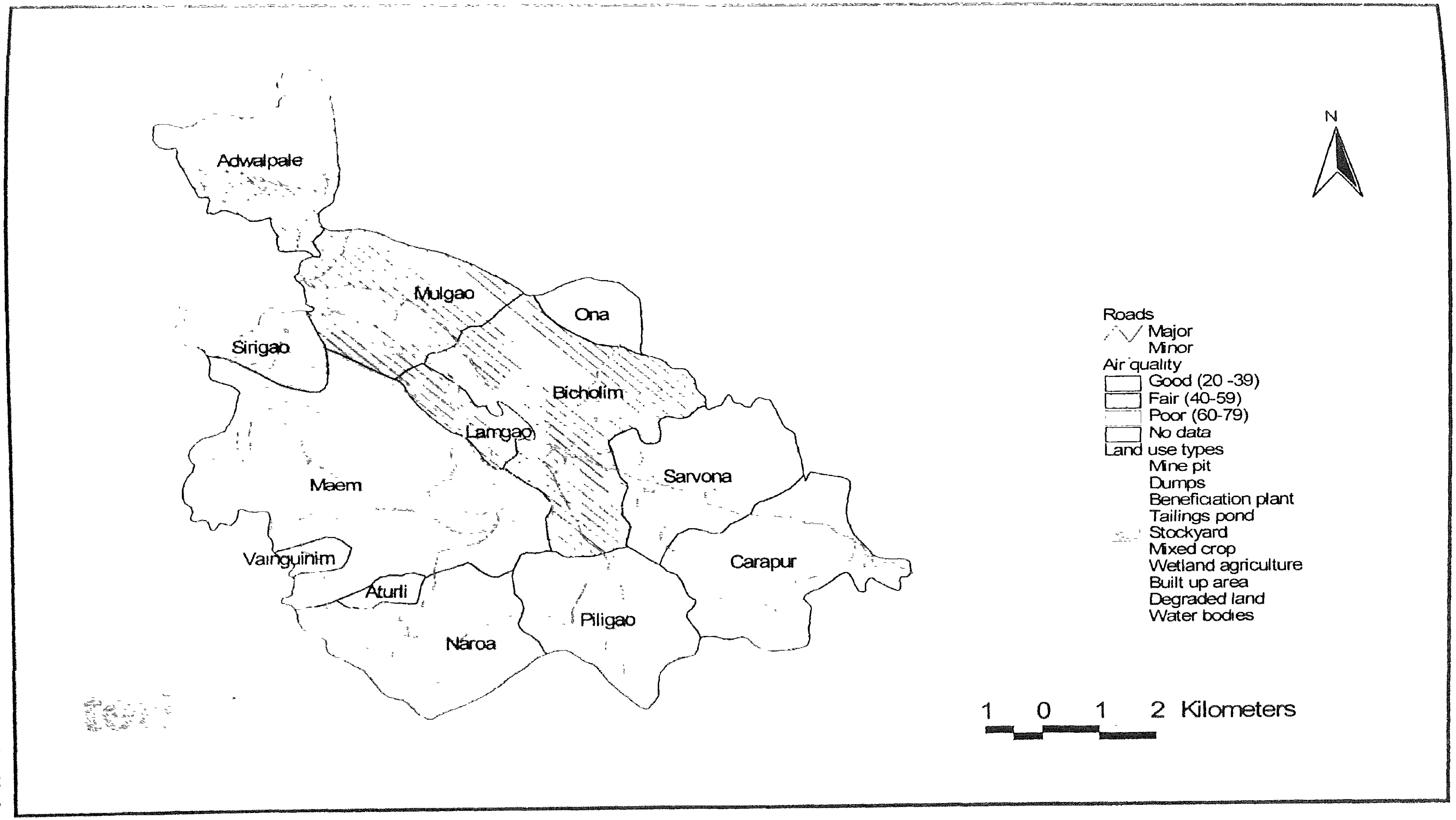


Figure 3. 26 Air quality index - cluster I

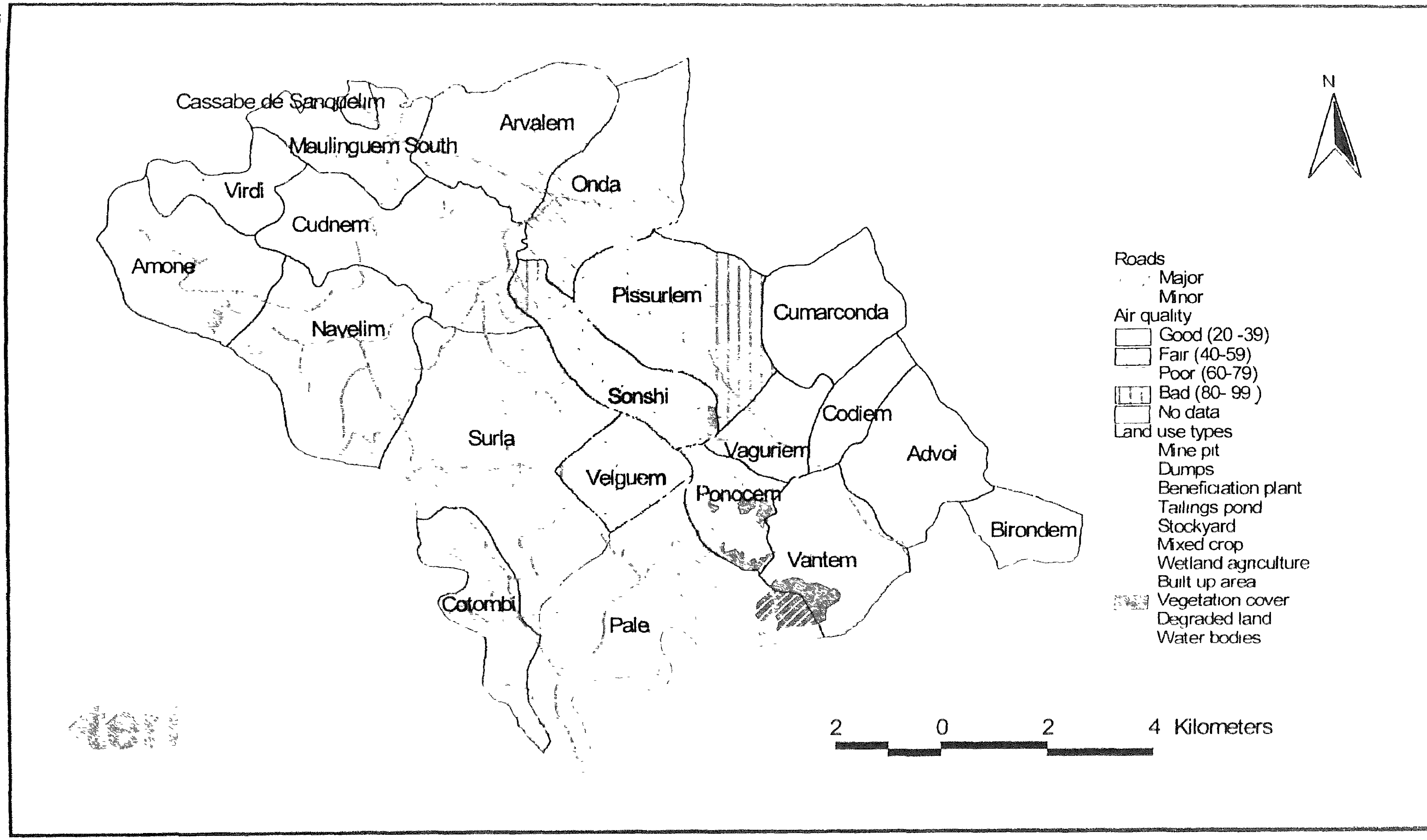


Figure 3. 27 Air quality index - cluster II

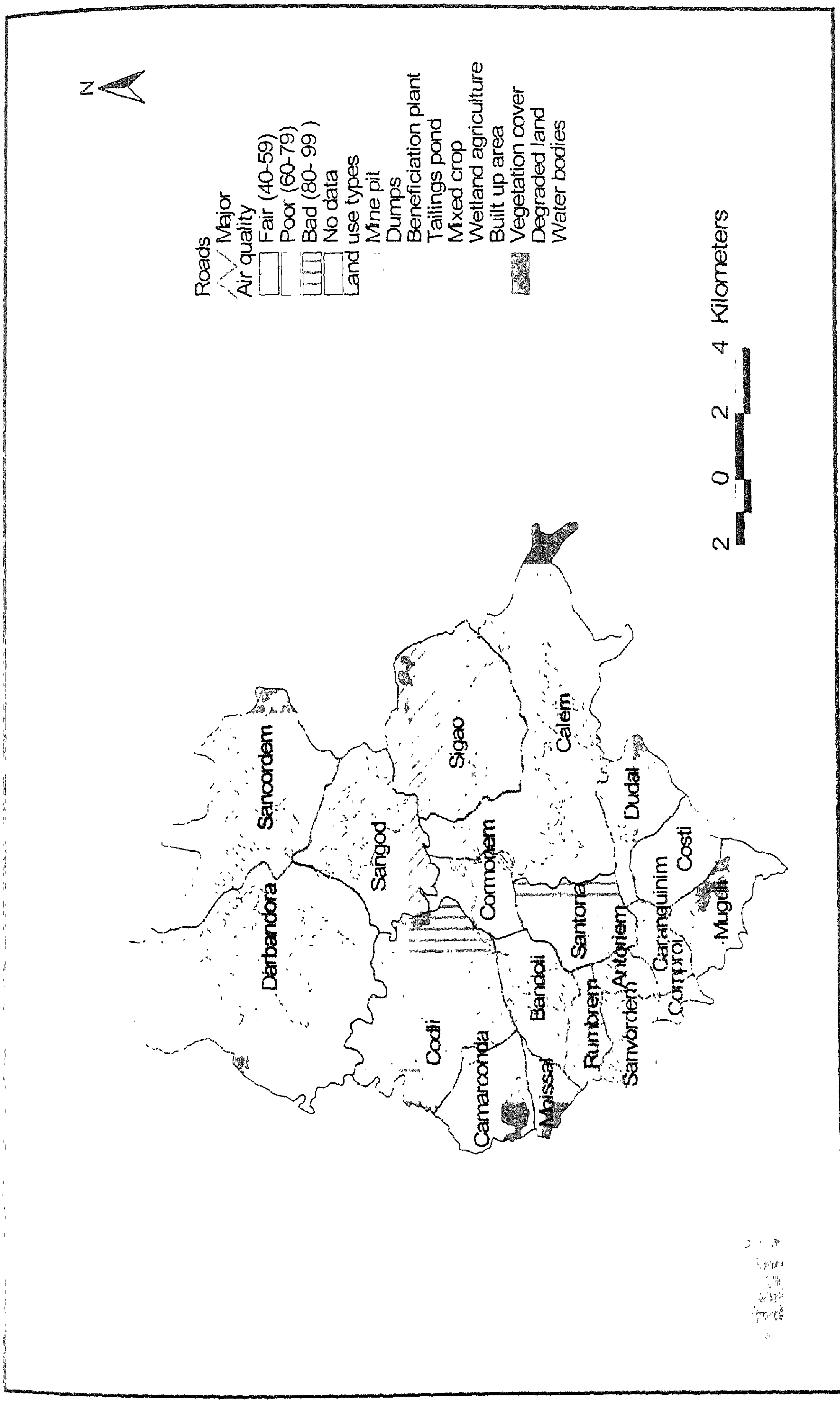


Figure 3. 28 Air quality index - cluster III

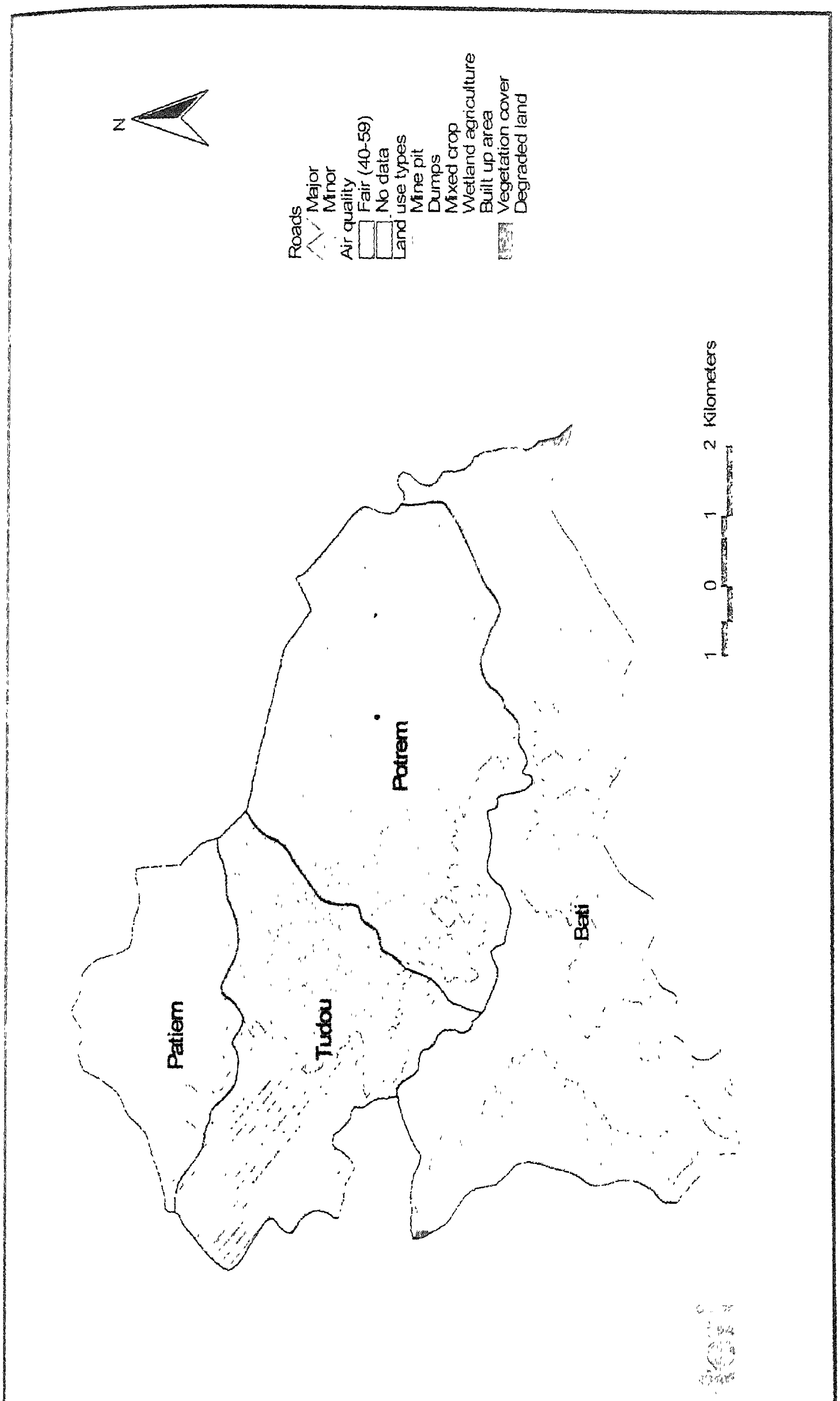


Figure 3.29 Air quality index - cluster IV

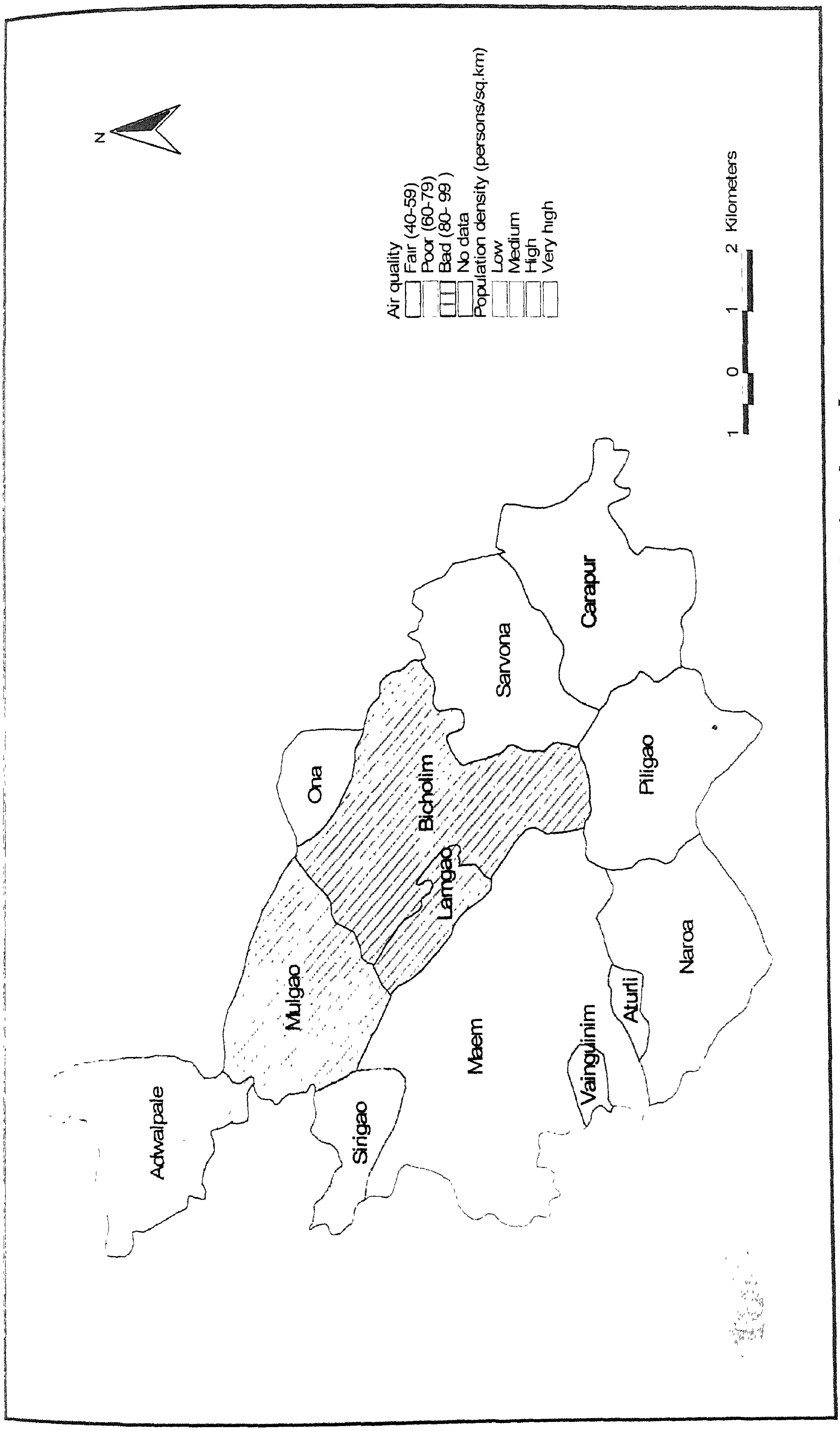


Figure 3. 30 Air quality and population density- cluster I

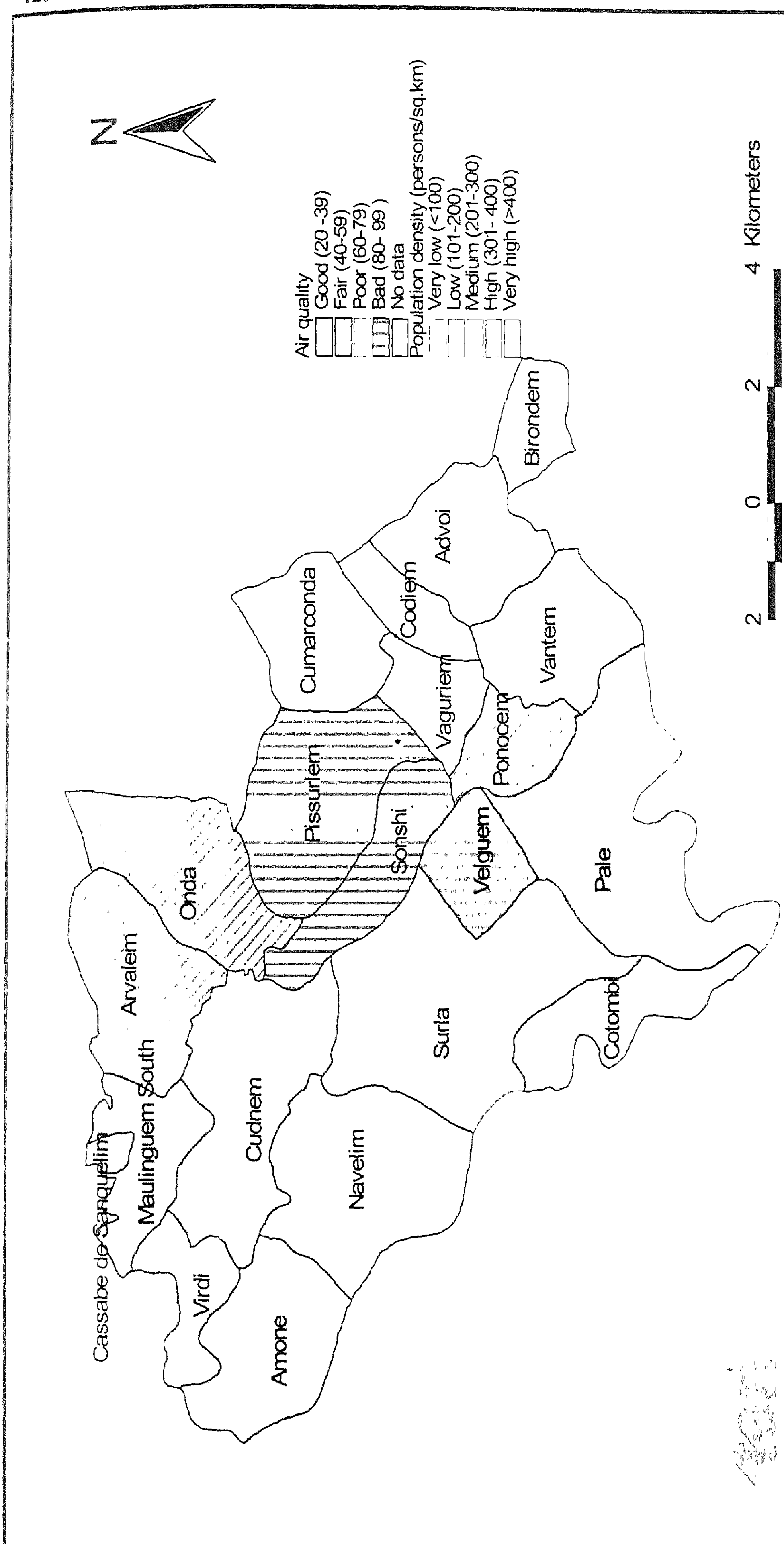


Figure 3. 31 Air quality and population density - cluster II

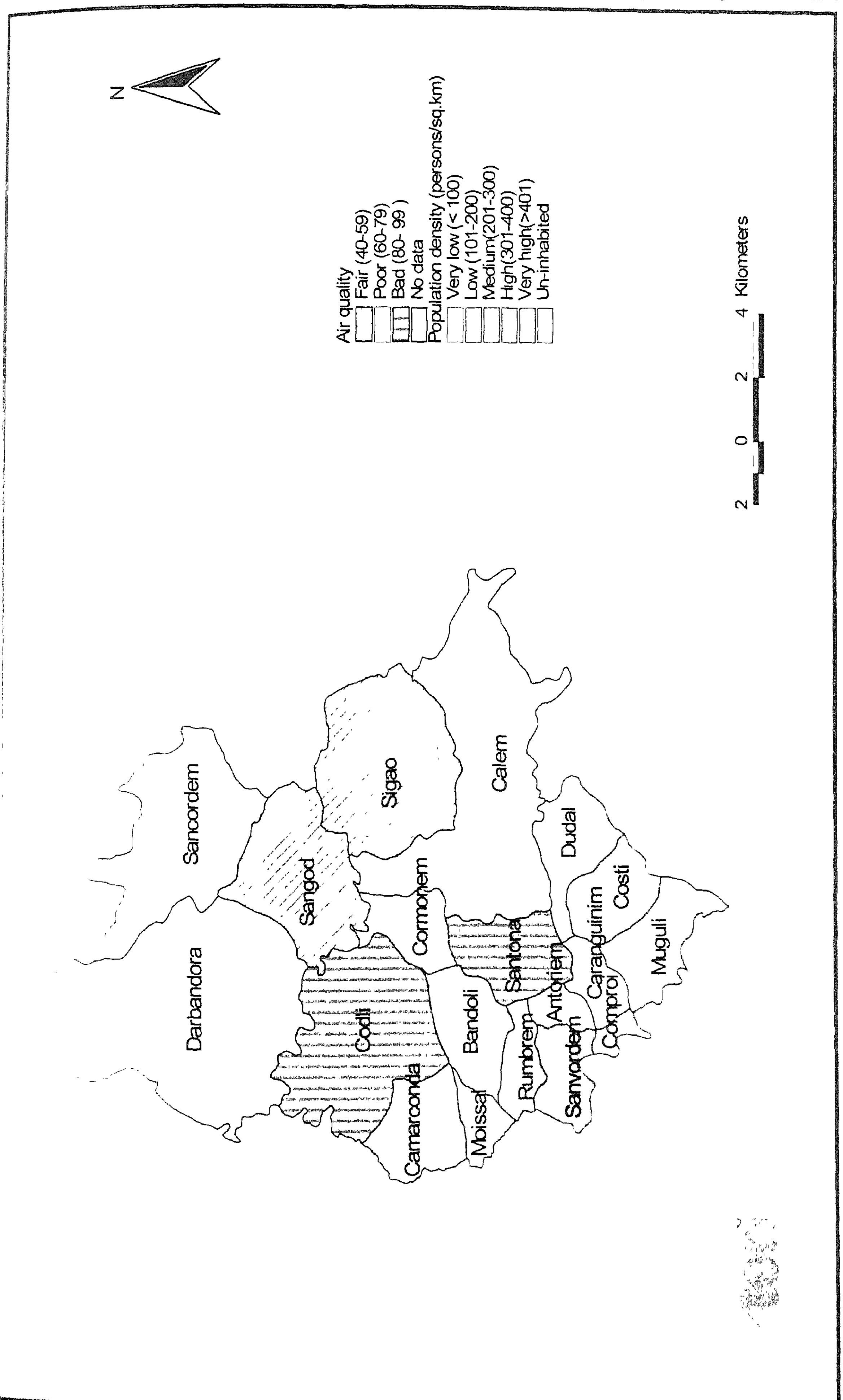


Figure 3.32 Air quality and population density - cluster III

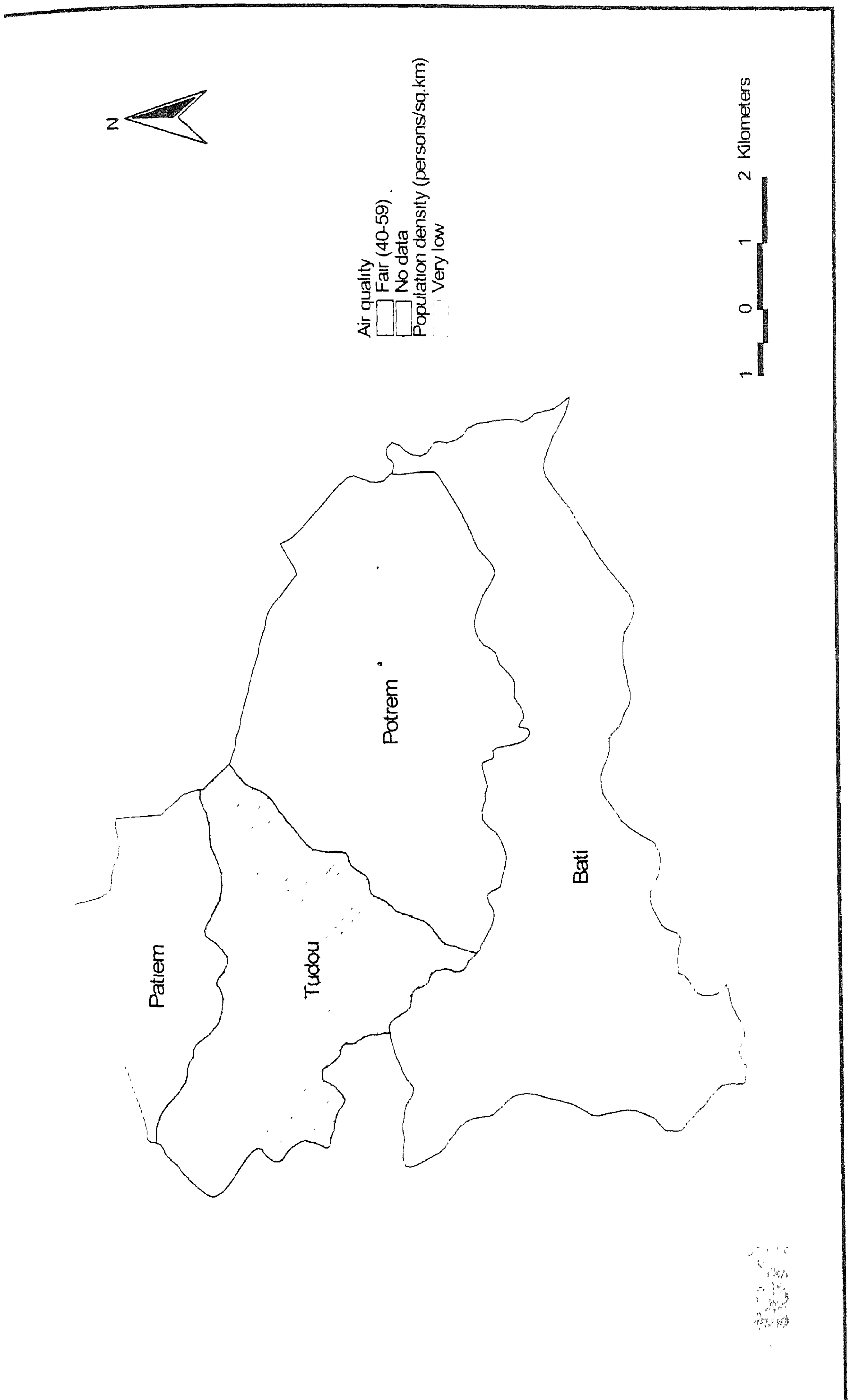


Figure 3.33 Air quality and population density - cluster IV

Water

Ambient water quality standards

The surface water are classified into five classes which reflects different use patterns Similarly, there are general discharge standards for inland surface water, public sewers, irrigation land and marine coastal areas The inland water classification are given in Table 3 15 The discharge standards are given in Annexure 3 8

Table 3.15. Classification of inland surface water, CPCB standard

Characteristics	A	B	C	D	E
Dissolved oxygen (mg/l), min	6	5	4	4	
Biological oxygen demand (mg/l), max	2	3	3		
Total coliform (MPN/100 ml), max	50	500	5000	-	
Total dissolved solids (mg/l), max	500	-	1500		2100
Chloride as Cl (mg/l), max	250	-	600		500
Colour, Hazen units, max	10	300	300		-
Sodium absorption ratio, max	-		-	-	26
Boron as B (mg/l), max	-		-	-	2
Sulphates as SO_4 (mg/l), max	400		400		1000
Nitrates as NO3 (mg/l), max	20		50		-
Free Ammonia as N (mg/l) max				1.2	
Conductivity at 25 C (us/cm) max				1.0	2.25
pH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.0-8.0
Arsenic as As (mg/l) max	0.05	0.2	0.2		-
Iron as Fe (mg/l) max	0.3		50		
Fluorides as F (mg/l) max	1.5	1.5	1		
Lead as Pb (mg/l) max	0.1		0.1		
Copper as Cu (mg/l) max	1		1.5		
Zinc as Zn (mg/l), max	15		15		

A Drinking water source without conventional treatment but after disinfection
B Outdoor bathing organized
C Drinking water source with conventional treatment followed by disinfection
D Propagation of wildlife and fisheries
E Irrigation industrial cooling, etc

Surface water quality in the mining area

River and lake water quality

Goa being on the watershed zone of Western Ghats has a number of rivers namely Mandovi, Zuari, Tiracol and Chapora flowing westward into the Arabian Sea. Rivers Mandovi and Zuari flow through the mining area and transport all the ore through barges from various loading points to the Marmagao harbour In fact, these rivers contribute substantially to the sustainability of mining operations in Goa Various tributaries of these rivers flowing within the study area are Bicholim, Assanora, Madei, Arvalem, Velguem and Kalay The important streams and nallahs are Kudnem, Dhonkal, Sonshi and Advoi. The lakes in the study area are Maem, Mulgao and Moissal.

The water quality of some of these rivers and lakes in the mining area is given in Table 3 16 These results are based on data collected from mining companies and other reports Nayak (1993) has carried out a detailed study for the Maem lake and the seven reverine systems of the Bicholim taluka. Various physico-chemical parameters were analyzed and the results are shown in Table 3 15 In their study, the water samples were not analyzed for biological and bacteriological parameters such as BOD, feacal coliforms, MPN, etc. In the absence of this information, it is very difficult to comment on the water quality with fair degree of reliability and accuracy Furthermore, the water quality have been monitored at one discrete point and as such could not represent the entire length of the river Therefore, it is difficult to quantify the impacts arising due to mining activities But, considering the fact that the mine dump runoffs, beneficiation plant effluents and pit water do not have organic pollutants, therefore, it can be assumed that the water of the rivers would fall in class B or class C of CPCB ambient water classification

Similarly water quality of Mulgao lake and other Rivers are also given in the table Khandepar river water quality is being continuously monitored by PWD at Opa water works The values given in the table are the maximum observed values of a particular season It is observed that there are fluctuations in the turbidity of river and in rainy season the turbidity is very high, sometimes of the order of 1500 NTU These fluctuations in the turbidity of the river reflects that the prevention measures of mining companies are not very effective

Table 3.16. Water quality of some rivers and lakes

Rivers/lakes	Season	DO (mg/l)	pH	SS (mg/l)	TDS (mg/l)	Na (mg/l)	K (mg/l)	COD (mg/l)	BOD (mg/l)
Maem lake	Pre-monsoon	4.0	6.2	3.0	158	4.2	1.3	NA	NA
	Monsoon	5.6	6.1	2.6	132	3.3	0.7	NA	NA
	Post-monsoon	4.2	6.5	1.8	30	3.7	0.8	NA	NA
Velguem	Pre-monsoon	5.1	5.4	3.0	98	6.4	2.2	NA	NA
	Monsoon	4.7	6.1	8.3	18	2.9	0.8	NA	NA
	Post-monsoon	4.6	6.1	6.2	30	4.4	1.3	NA	NA
Harvale	Pre-monsoon	4.3	6	4.1	106	5.3	1.5	NA	NA
	Monsoon	5.4	6.6	1.9	52	2.2	0.6	NA	NA
	Post-monsoon	5.4	6.9	6.2	30	3.7	0.8	NA	NA
Harvale canal	Pre-monsoon	3.8	5.9	2.0	158	4.6	1.4	NA	NA
	Monsoon	4.8	6.7	7.0	30	3.3	0.7	NA	NA
	Post-monsoon	5.0	6.8	7.0	24	2.9	0.6	NA	NA
Sanquelim	Pre-monsoon	4.7	6.2	2.0	2282	4.4	1.6	NA	NA
	Monsoon	5.4	6.7	1.6	20	3.4	0.8	NA	NA
	Post-monsoon	5.1	6.7	1.6	172	4.5	1.3	NA	NA
Bicholim	Pre-monsoon	2.8	5.9	3.5	486	35	11.2	NA	NA
	Monsoon	4.8	6.4	1.2	18	3.6	0.7	NA	NA
	Post-monsoon	5.5	6.8	2.5	52	5.2	1.2	NA	NA
Assonara	Pre-monsoon	4.0	5.9	12.6	39	150	100	NA	NA
	Monsoon	5.8	6.4	2.1	100	17.4	[illegible]	NA	NA
	Post-monsoon	5.3	6.7	2.3	308	7.2	7.1	NA	NA
Kasarpal	Pre-monsoon	4.4	5.9	20.6	[illegible]	11.2	37.6	NA	NA
	Monsoon	4.6	6.4	2.5	36	4.1	1.5	NA	NA
	Post-monsoon	5.0	6.7	11.4	70	6.1	0.8	NA	NA
Pilgaon	Pre-monsoon	3.2	6.5	22.0	38760	150	100	NA	NA
	Monsoon	5.2	6.8	11.5	160	33.1	4.7	NA	NA
	Post-monsoon	4.1	6.8	12.0	10240	150	100	NA	NA
Sanguem	Average	5.2	7.3	67	72	NA	NA	1.5	14.7
Made	Average	6.0	7.0	15	28	NA	NA	Nil	Nil
[illegible]	Average	4.8	6.8	69	62	NA	NA	10	[illegible]
Mulrao lake	Average	6.1	7.2	NA	33.5	NA	NA	3.2	7.2
		Turbidity (NTU)	pH	Sp. Conductivity	T. Hardness	T. Alkalinity	Chlorides	DO	Temp
Khandepar	Pre-monsoon	190	7.1	68	38	34	6.5	7.2	22
	Monsoon	215	6.8	38	14	1[illegible]	6.5	7.5	23
	Post-monsoon	210	6.8	38	18	17	6.0	7.6	23

NA Not available

Mine water quality including runoff water and effluents

Mine pit water The mine pits are classified into dry and wet pits. The dry pits (See Photo 8) are those where the mines are operating above ground water table and therefore remain dry throughout the year except in monsoon Wet pit mines (See Photo 9 and 10) are operating below ground water table and therefore discharge water throughout the year The pit water is slightly acidic and has high concentration of suspended and dissolved solids. The typical characteristics of pit water is given below which is interpreted from the results of 26 samples as reported in EMP of mines and IBM survey reports

Colour	-	Red
pH	-	5 0 - 6 5
Dissolved solids (TDS)	-	33 - 1269 mg/l
Suspended solids (SS)	-	12 - 3840 mg/l
Dissolved oxygen (DO)	-	90 % saturation
Biochemical Oxygen Demand (BOD)	-	0 4 - 8 mg/l
Chemical Oxygen Demand (COD)	-	18 - 30 mg/l

Goa's iron ore does not contain any toxic substances like lead, arsenic etc and therefore, the pit water is non toxic to biological life. However, if the pit water is discharged into the rivers without any control, it will impart turbidity and make the water unfit for drinking (See Photo 11) The analysis results of mine pit water show a wide variation in suspended solids concentration The values are specially high during rainy season since the water runoff from mining area is accumulated in pits

Beneficiation plant effluents The beneficiation process is basically a desliming process where the lighter sticky aluminous and silecious material is removed and the ore is scrubbed and cleaned, heavier and coarser particles of ore are thus enriched Overflow from the hydro-cyclones (tailings) is passed through a thickener and sent to the tailing pond Many beneficiation plants are located on the bank of Mandovi river and withdraw water from the river for consumption The seepage/ overflow of the tailing ponds is discharged back into the river Where the tailing ponds have fairly good capacity, water comes out in the form of seepage only which has fairly good quality The overflow from the tailing ponds has high SS and TDS concentration The characteristics of tailing water discharge as reported in various EMP and IBM survey is given below

pH	-	6 0 - 6 5
Dissolved solids (TDS)	-	83 - 6917 mg/l

Suspended solids (SS)		
In seepage water	-	12 - 20 mg/l
In overflow water	-	76 - 2676 mg/l
Dissolved oxygen (DO)	-	90 % saturation
Biochemical Oxygen Demand (BOD)	-	0.43 - 20 mg/l
Chemical Oxygen Demand (COD)	-	40 - 86 mg/l

The beneficiation plants don't operate during monsoons. Therefore, the impact of beneficiation plants on the water resources are only in non-monsoon season. The high concentration of dissolved solids increases the electrical conductivity of the water and makes the water unfit for irrigation.

Runoffs from mine dumps The study area receives intense rainfall of the order of 3000 - 4000 mm during the South-West monsoon causing large run off and vigorous stream flows. Soil erosion and run-off from mine dumps is discharged into the rivers, streams and nallahs resulting in heavy silting in the beds in many stretches. They also get deposited in adjoining land areas including agricultural land. The typical characteristics of dump runoffs as found in the analysis reports of mining companies and IBM Nagpur are given below.

Colour	-	Red
pH	-	6.0 - 7.1
Dissolved solids (TDS)	-	36 - 244 mg/l
Suspended solids (SS)	-	102 -4212 mg/l
Dissolved oxygen (DO)	-	10 - 90 % saturation
Biochemical Oxygen Demand (BOD)	-	0 - 20 mg/l
Chemical Oxygen Demand (COD)	-	0 - 60 mg/l

The impact of dump runoffs on river water quality is only in monsoon period from May to November but their effect on water bodies remains throughout the year. The runoffs from mine dumps carries huge amount of mine rejects which are finally deposited on land or on river beds. In a study by Sen Gupta (Ecoforum, 1993) estimated that about 70,000 tonnes of run-off materials is deposited every year in the Mandovi river.

Barge movement

Water quality of the river is also affected by the accidental discharges of oil or other pollutants from the boats. Propeller of the boat resuspend the bottom sediments and increases water turbidity. This results in decrease in dissolved oxygen contents which affects fish life. No scientific study has been carried out in Goa on the impact of barge movement on the water quality of the river. The concentration of oil and grease in inland water is between 0.2 to 9.2 mg/l, with occasional high values. However, it is observed that the stretch of river where the

barge movements are taking place are already saline due to the ingress of sea water and can be best used for navigation or aquatic life propagation.

Workshop effluents

Most of the mining companies have workshops in their facilities for maintenance and servicing of trucks. These workshops generates effluent which has high concentration of oil and grease Except for Codli mine of M/s Sesa Goa, none of the mining company have the facilities for oil and grease removal from the effluents before discharge.

Water requirements for servicing of a vehicle is in the range of 400-750 liters. The general characteristics of wastewater from automobile service station are as below

pH	7.3 - 8.2
Total Solids (mg/l)	1350 - 6520
Total Dissolved Solids (mg/l)	700 - 1930
Total suspended solids (mg/l)	650 - 4590
Oil & grease (mg/l)	27 - 140
BOD (mg/l)	85 - 250
COD (mg/l)	290 - 920

The quantity of grease released by a mine is estimated to be 100 to 250 kgs/ mine. The treatment of workshop effluent has been ignored by the mining companies and therefore, needs immediate attention

Impacts due to mining activities

Mining affects the hydrological regime and water quality of rivers by direct discharge of mine water to the streams (See Photo 11) and due to erosion and wash-off from the mined out area and waste dumps. The factors contributing to pollution of water bodies are

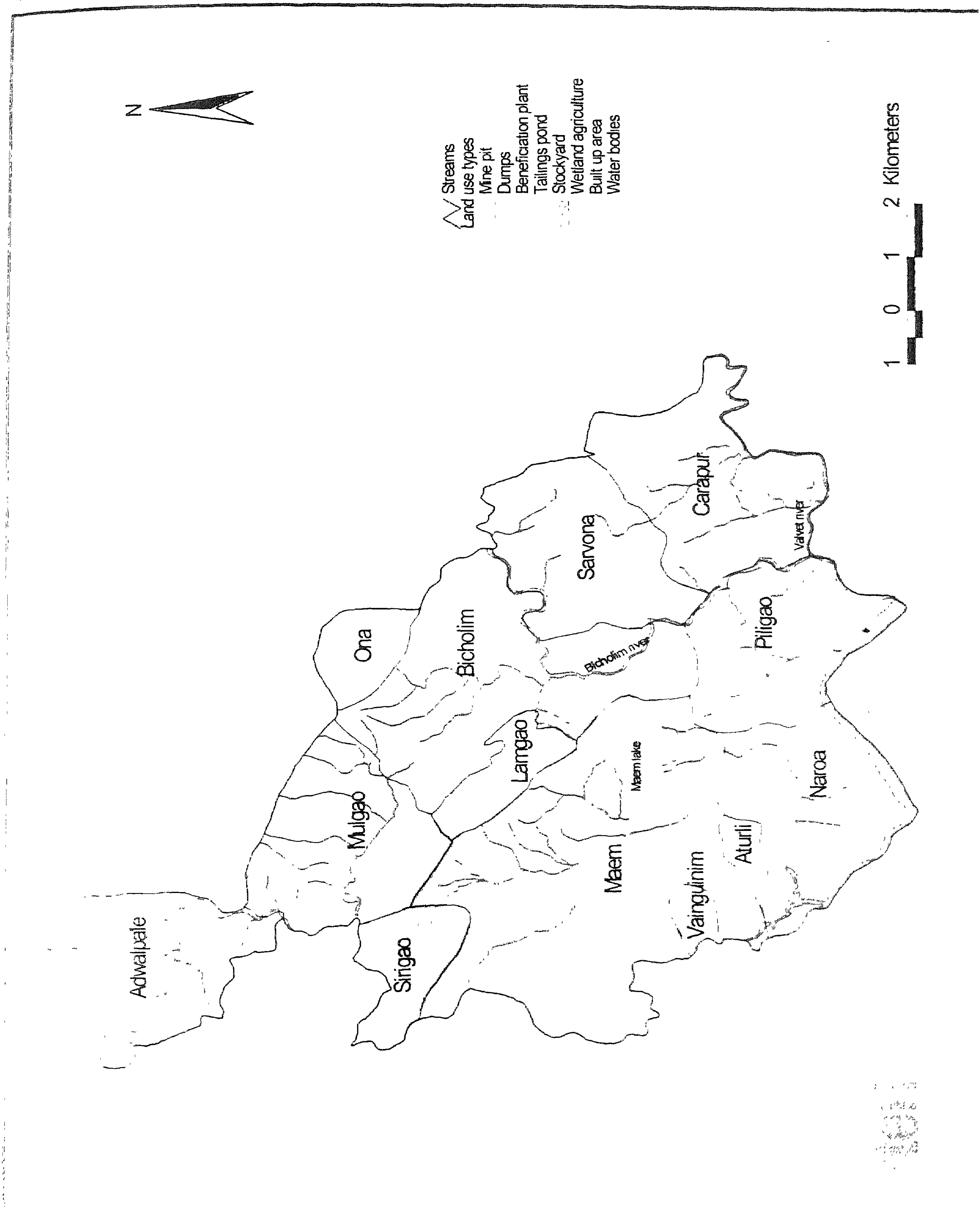
- Discharge of the mine pit water
- Wastewater from the wet beneficiation plants
- Rainwater run off from the dumps
- Barge movement
- Effluent from workshops

A survey conducted under this study reveals that the water resources in the study area are applied in more than one beneficial use. The most prominent uses are domestic and irrigation The water quality requirements for domestic use are most stringent and therefore requires strict preventive measures to keep the rivers clean.

The major effect of mining activities on the river quality is the presence of high turbidity due to discharge of silt particles. The worst affected rivers are Bicholim, Madei and Khandepar. Bicholim river is polluted mainly from the runoffs from dumps and beneficiation plants at

Bicholim mine Madei river is polluted due to mines and dumps at Pale village Khandepar river is polluted due to washoffs from the dumps of Codli-Kirlapal, Bimbol-Sigao and Odamol - Tathodi group of mines. Some of the mines have their dumps right on the banks of rivers, from which wash-off flow directly into the river during rainy season.

Impact assessment on surface water resources by mining activities for each village has been done through satellite imagery (1997) interpretation. The interpreted maps for each cluster are presented in Figures 3.34 to 3 37 The maps show the rivers, mining activities and land use features in each village. The interpretation of the maps and impacts assessment for each village is given in Table 3.17. The table shows the mining activities, surface water resources, impacted length of the factors leading to these impacts and the rivers and nallahs, and the land uses affected due to siltation.


N
Streams
Land use types
Mine pit
Dumps
Beneficiation plant
Tailings pond
Stockyard
Wetland agriculture
Built up area
Water bodies
1 0 1 2 Kilometers
Carapur
Valvet river
Sarvona
Piligao
Bicholim river
Ona
Bicholim
Lamgao
Maem lake
Naroa
Mulgao
Aturli
Maem
Vaingulnim
Adwalpale
Singao

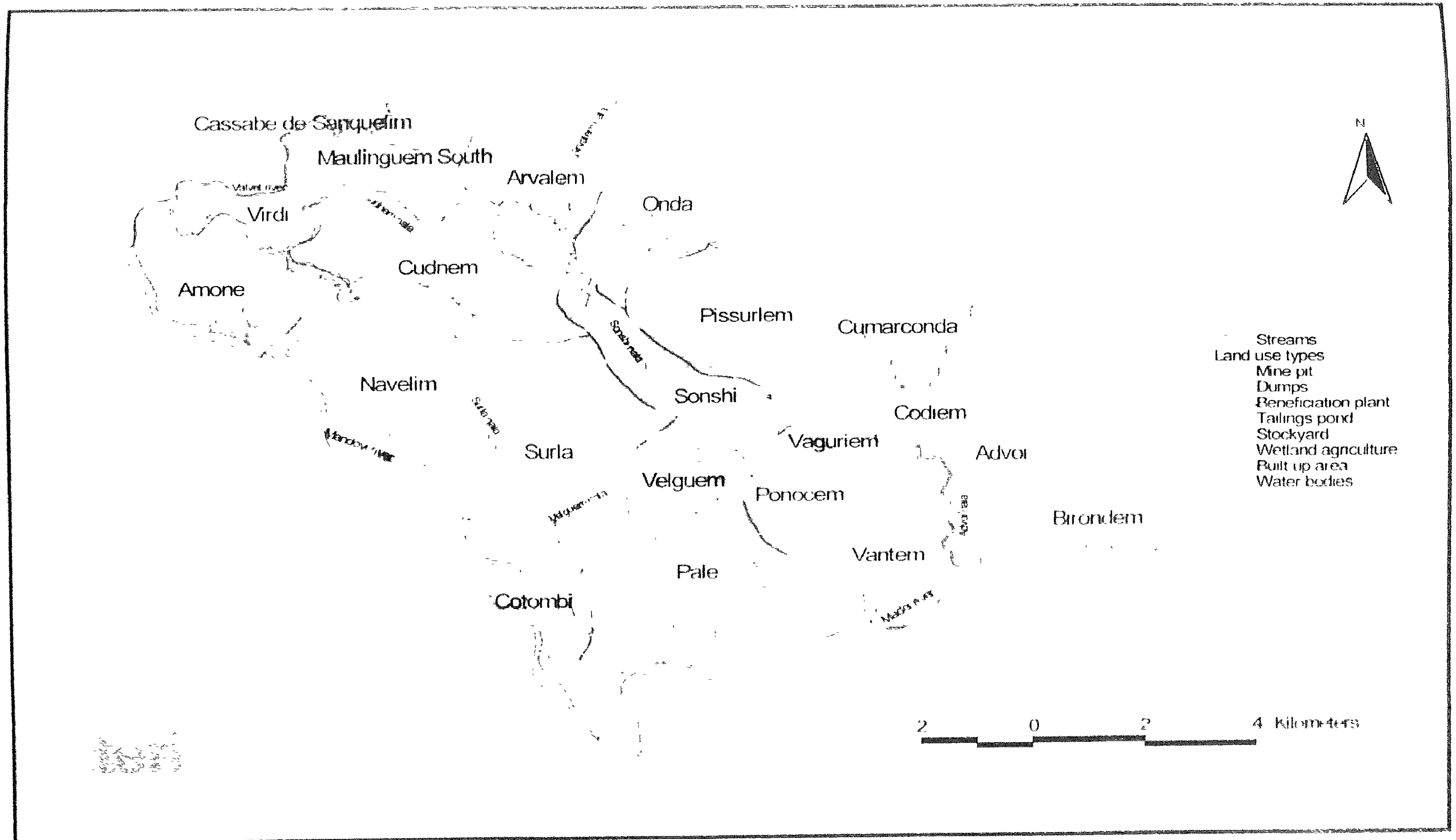


Figure 3. 35 Water resources and mining activities - cluster II

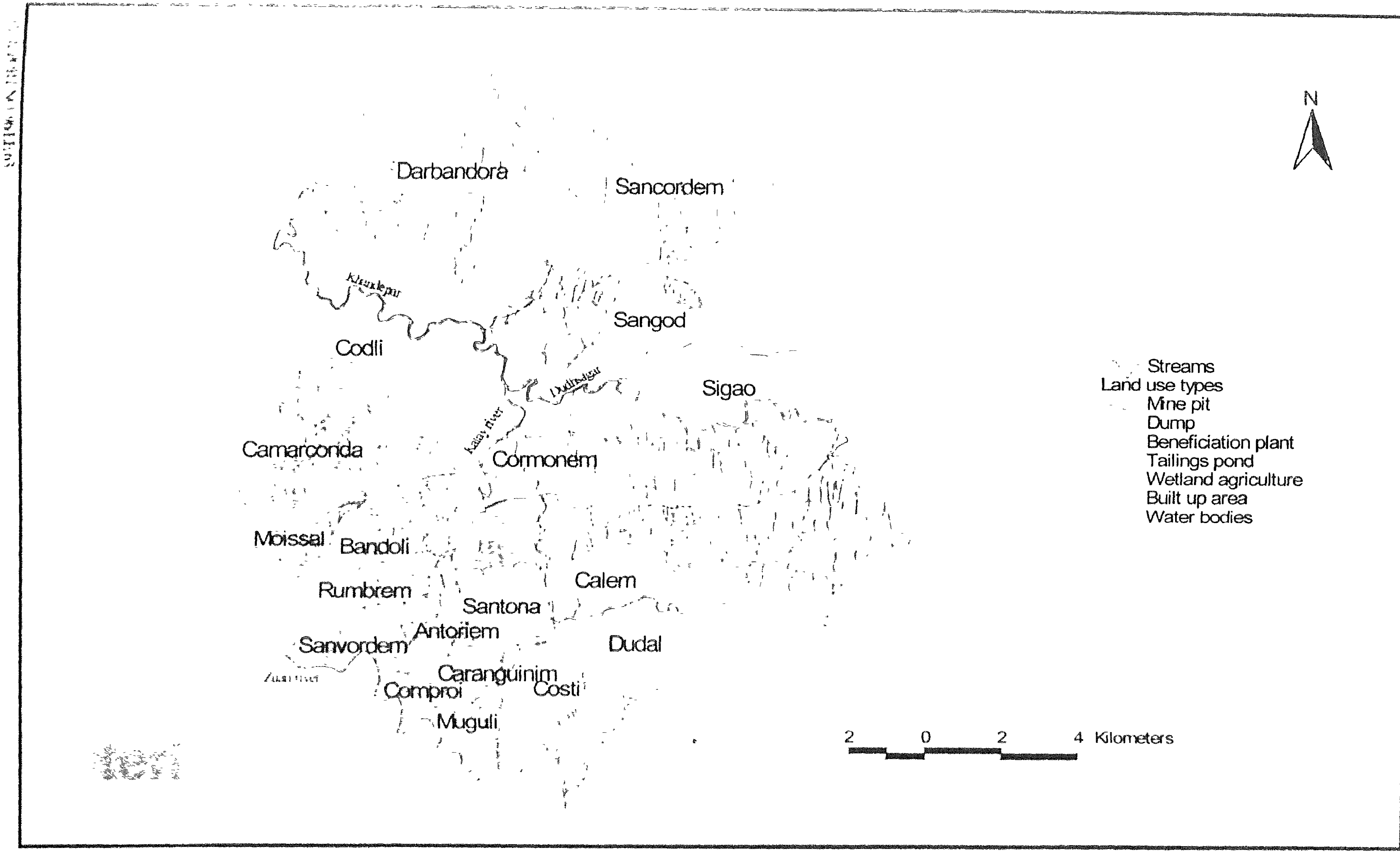


Figure 3. 36 Water resources and mining activities - cluster III

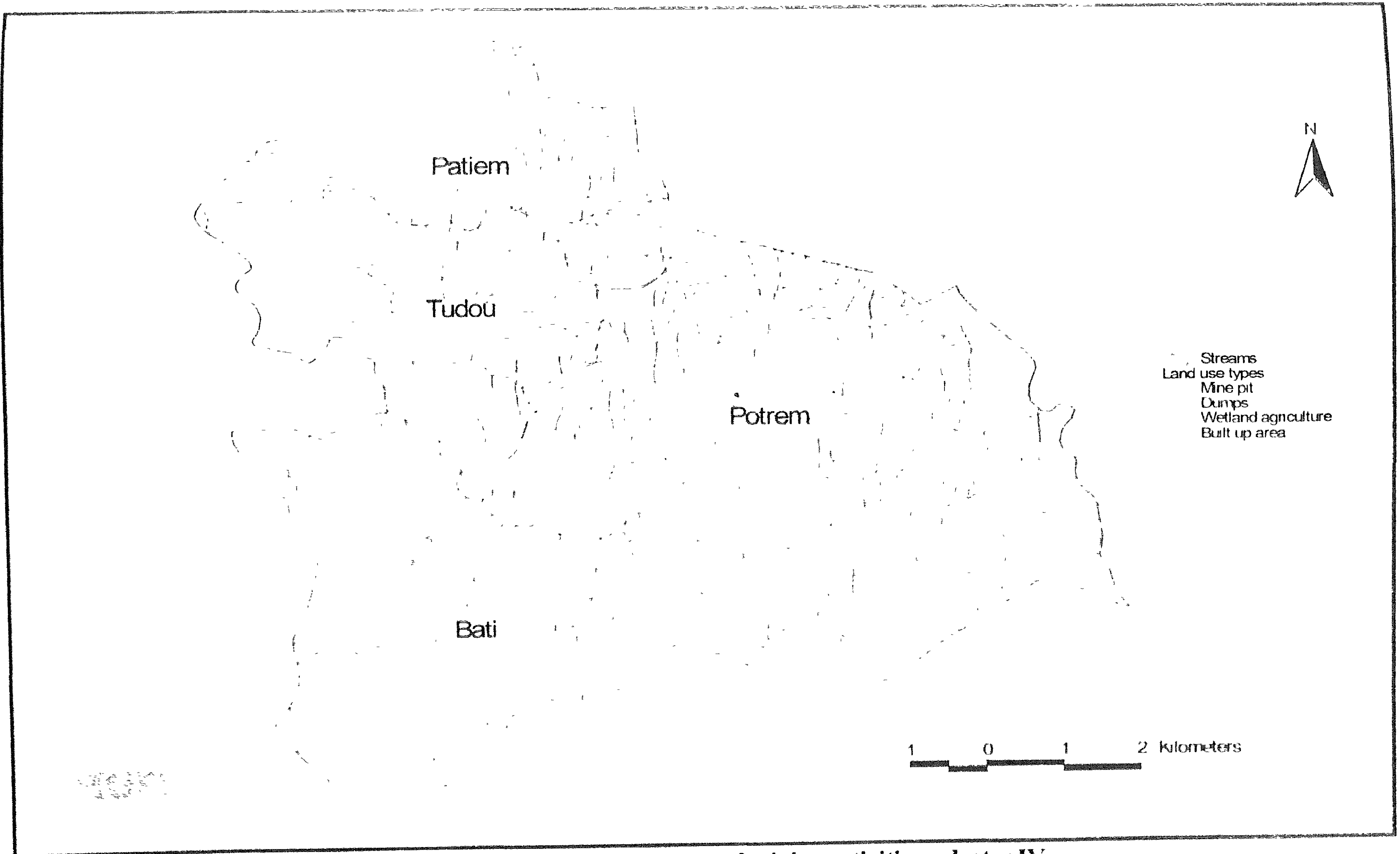


Figure 3.37 Water resources and mining activities - cluster IV

Table 3.17. Impacts on water bodies due to mining activities in villages

Village Name	Mining Activities	Water bodies and total stretch (km)	Impacted stretch (km)	Contributing factors	Land uses affected due to siltation/effluent discharge/surface run-offs
Cluster I					
Ona	None	None	Nil	None	None
Bicholim	Mine dumps - 8 Pits - 4	Bicholim river - 7 25	3 15	Effluent from 2 tailing ponds and confluence of silted Lamgao stream	Of the impacted stretch settlements are along the 1 8 km stretch 4 hec paddy field is affected
	B Plant - 1 T Pond - 2	Lamgao Stream- 1 4 Other streams - 9 4	1 4 Nil	Carries silts due to runoffs from mine dumps at Lamgao village	Settlements are along the entire stretch of Lamgao stream 7 hec of paddy field is affected
Lamgao	Mine dumps-9 Pits - 3 B Plant - 1	Lamgao stream - 1 4	discussed above	Discussed above	Two streams flowing in Maem village originates from two mine dumps at Lamgao The impacts from these are discussed in Maem village
Vainguinim	None	Assonara - 0 9	None	None	None
Aturli	None	None	Nil	None	None
Sirigao	Pits - 5 Mine dumps - 7 Stockyard - 1	Assonara - 7 1	1 82	Stockyard and associated activities and the discharge of pit water The pit water travels a large distance before joining Assonara river	10 hac of paddy fields are affected due to mining activities in this villages
Naroa	None	Mandovi 2 55 Assonara 11 11 Other streams - 5 24	Nil Nil Nil	None	None
Maem	Mine dump - 33 Pits - 7	Other streams - 19 22	7 3	Runoff from 18 mine dumps and seepage water from a tailing pond	4 hec of paddy fields are affected
	T Ponds - 1 B Plants 2	Assonara - 8 55 Maem Lake	1 39 Nil	Runoffs from 5 mine dumps and a stock yard located in Sirigao village	
Pilligao	Stockyard 1	Sanquelim - 1 84	Nil		Other than mining operations, there is no mining economic activities along the impacted stretches
	B Plant 1	Mandovi - 2 41	0 5	Stockyard	
	Mine dumps 1	Bicholim - 2 43	Nil		
	Tailing Pond 2	Other Stream 6 54	0 5	Beneficiation Plant	

Village Name	Mining Activities	Water bodies and total stretch (km)	Impacted stretch (km)	Contributing factors	Land uses affected due to siltation/effluent discharge/surface run-offs
Carapur	None	Bicholim river stretch is already accounted in Pilgao	Nil		
		Sanquelim river is discussed under cluster II villages	Entire stretch	Mining activities of neighboring villages of cluster II	63.54 hac of paddy fields situated along the bank of the Sanquelim river is attected
		Other streams - 9.62	Nil		
Sarvona	None	Bicholim river stretch is already accounted in the Bicholim town	Nil	None	None
		Other streams - 3.72	Nil	None	None
Advalpale	Pit - 2 Mine dumps - 4	Other streams - 11.7	1.35	One wet pit and one mine dump	People are settled along the 0.57 km of the impacted stretch
Mulgao	Pit - 3	Assonara - 1.38	Nil	None	None
	Mine dumps - 9	Other streams - 12.3	Nil	None	None
	B Plant - 1	Mulgao lake	Nil	None	None
Cluster II					
Sanquelim	None	Sanquelim - 0.34	Nil	None	None
Maulinguem [illegible]	Mine dump - 13 Pit - 6 B Plant - 1 T pond - 4	Cudnem Nallah - 2.76	2.76	Runoffs from 6 dumps present in adjacent Cudnem village and upstream mining activities	Of the impacted stretch of Cudnem nullah the settlements are along the 0.65 km length
		Other streams - 1.59	1.59	5 dumps, 1 wet pit & 2 tailing ponds	Of the impacted stretch the settlements are along the 0.3 km stretch
		[illegible] - 2.36	1.23	1 dump and two wet pits	
Arvalem	Pits - 4 Mine dumps - 2	Other streams - 3.3	1.0	4 mine pits and 1 dump	Except for mining there is no other economic activity along the impacted stretch
		Assonora river - 4.7	Nil		
		[illegible] - 2.33	2.33	Due to upstream mining activity	
		[illegible] nallah - 0.53	0.53	Due to upstream mining activity	

Village Name	Mining Activities	Water bodies and total stretch (km)	Impacted stretch (km)	Contributing factors	Land uses affected due to siltation/effluent discharge/surface run-offs
Onda	Pits - 2 Mine dumps - 3 B Plant - 1	Other streams - 6 91 Sonshi nullah - 1 8	Nil 1 8	– Upstream mining activities	 Settlements are along the 1 2 km stretch of sonshi nallah
Cudnem	Pits - 6 Mine dumps-20 B Plant - 1	Sonshi and Cudnem nullah are discussed in the above three villages Other streams - 2 12 (joining Cudnem nullah)	Discussed above 2 12	Discussed above runoff from mine dumps and discharge from 4 pits	 Settlements are along the 0 35 km impacted stretch
Sonshi	Pits - 11 Mine dumps-16 B Plant - 1	Sonshi nullah - 3 8 Tributary of Advai-5 7	3 8 2 31	All mining activities in the village Mine dumps	About 20 hectares of land is silted on both sides of nullah In 1980's there were paddy fields which are not existing now None
Birondem	None	Madei - 1 6 Other streams - 2 74	Nil Nil	None	None
Pissurlem	Pits - 10 Mine dumps-12 B Plant - 1	Pissurlem nullah-2 6 Advai tributary - 1 15	Nil 0.8	 5 dumps, 3 pits	 24 hectares paddy fields.
Surla	Pit - 6 Mine dumps-18 B Plant - 1 Stock yard - 1	Surla nullah - 8.23 Velguem river - 1 62 Other stream - 1 66 Mandovi - 2 8	1 81 Nil 0 6 1 3	Confluence of silted Surla nullah 2 dumps Stockyard and related activities	6.86 hectares paddy field No other economic activity except for mining None
Velguem	Pits - 3 Mine dumps-14	Velguem river - 2 4	0.93	2 dumps of this village and 3 dumps from adjacent village	16 hectare paddy fields are affected due to mining activities.
Pale	Pit - 6 T Ponds - 2 B Plant - 1 Mine dumps-32	Madei river - 8 5 Other streams - 11 06 Mandovi - 0 87	2 17 3 65 Nil	2 pits & 5 dumps 1 tailing pond and 7 mine dumps	14 84 hectare paddy fields are affected

Village Name	Mining Activities	Water bodies and total stretch (km)	Impacted stretch (km)	Contributing factors	Land uses affected due to siltation/effluent discharge/surface run-offs
Colomba	Mine dumps - 2 Pit - 1 B Plants - 2 T Ponds - 1 Stockyards - 5	Mandovi river - 6 45 Other streams - 2 95	6 45 1 37	Stockyards and related activity 4 dumps and one stockyard	26 76 hec paddy fields are affected Of the impacted stretch settlements are along the 0 62 km stretch
Advoi	None	Advai river - 2 08 Other streams - 2 22	Nil Nil	None	None
Codiem	None	Advoi river - 3 34 Other Stream - 0 83	Nil Nil	None None	None
Vantem & Ponocem	Mine dumps - 7 Pits - 4	Vantem nullah - 4 19 Other streams - 4 09 (meets Adver nallah) Medai - 2 Adver - 1 06	1 9 Nil Nil Nil	Mine dumps	14 7 hectare land on both side of the nullah is silted
Cumarconda	None	Advoi river - 1 38 Other streams - 2 67	Nil Nil	None	None
Virdi	None	Valvet river - 2 77 Cudnem Nullah - 5 51	Nil Nil	None	None
Amona	Mine dumps - 1 Stockyards - 1 B Plant - 2 T Pond - 1	Mandovi river - 3 59 Other streams - 1 78 Surla nullah - 0 8	0 4 1 61 Nil	Stockyard and associated activities Mine dump and benificiation plant	None
Vagurem	None	Other stream - 2 0	Nil	None	None
Navelim	T Ponds - 2 B Plants - 1 Stockyards - 2 Pits - 1 Mine dumps - 1	Mandovi - 4 2 Other streams - 6 14 Surla nullah - already discussed in other village	1 53 0 4	One stockyard and related activity	about 5 hectare paddy fields are located in the impacted stretch

Village Name	Mining Activities	Water bodies and total stretch (km)	Impacted stretch (km)	Contributing factors	Land uses affected due to siltation/effluent discharge/surface run-offs
Cluster III					
Muguli	None	Zuari river - 3 23 Other streams - 16 8	Nil Nil	None	None
Comproi	None	Zuari river - 3 8 Other streams - 1 77	Nil Nil	None	None
Caranguinim	B Plants - 1 T Ponds - 3	Other streams - 10 53	0 46	Runoff from one mine dump and seepage water from two tailing ponds	The impacted stretch lies in forest area
Antoriem	Pits - 2	Other streams - 5 61	0 2	Discharge from the dry pits	The impacted stretch lies in forest area
Rumbrem	Pits - 2	Other streams - 5 96	Nil	None	None
Sanvordem	Pits - 1 Mine dumps - 2	Zuari river - 3.35 Other streams - 10 23	Nil 0 7	Due to discharge from dry pits	Impacted stretch passes through mixed crop field
Moissal	None	Other streams - 11 93	Nil	None	None
Camarconda	Pits - 1 Mine dumps - 1	Other streams - 7 55	0 55	Dump and pit	None
Bandoli	Mine dumps - 3 Pits - 4	Other streams - 15 5	1 3	Dumps and pits	None
Calem	Mine dumps - 5 Dry pits - 5	Kalay river - 20.2 Other streams - 56 1	0 5 0 3	Discharge from a dry pit One dry pit and a Benificiation plant	None Settlements are along the 0 2 km length of the impacted stretch
Dudal	Mine dump - 8 Pits - 6 T Ponds - 1	Kalay river stretch discussed in Kalay Other stream - 1 56	– 1 5	– Discharge from pits runoff from the dumps	– 2 hectare paddy fields are affected
Costi	Mine dumps - 6 Pits - 1 B Plants - 1	Other streams - 13 58	Nil	None	7 2 hectares of paddy fields are affected due to the presence of three mine dumps

Village Name	Mining Activities	Water bodies and total stretch (km)	Impacted stretch (km)	Contributing factors	Land uses affected due to siltation/effluent discharge/surface run-offs
Darbandora	Pits - 24 Mine dumps-22	Khandepar river 10 63 Other stream - 78 19 Ragada Nadi - 2 02	10 63 0 99 Nil	Due to the mining activities of this and adjacent village Details discussed under Costi village	6.3 hectare land is silted 15 4 hectares paddy fields are effected
Codli	Pits - 17 Mine dumps-24 B Plants - 2 T Ponds - 6	Khandepar river 9 34 Other streams - 29 57 Perineal stream - 7 0 Kalay river (The stretch is discussed in Cormonem village)	9.34 Nil Nil	Pit water discharge and runoff from mine dumps	Of the impacted stretch of Khandepar river settlements are along the 1 2 km stretch 45 3 hectares of paddy crop is affected due to mining activities in the village
Sancordem	Pits - 13 Mine dumps-10	Ragda river - 11 3 Other streams - 33.6	0 3 2 8	1 wet pit 3 dry pits and 5 mine dumps	None 8 8 hectares of paddy fields are located along the impacted stretch Of the impacted stretch settlements are along the 0.2 km stretch
Sangod	Pits - 9 Mine dumps- 8 T Ponds - 1	Khandepar river stretch is discussed in Codli village Dudhsagar - 4 9 Other streams - 27	Nil Nil Nil	None	4 hectares of paddy field is affected due to mine dumps
Cormonem	Pits -2 Mine dumps - 5 T pond - 7 B Plant - 1	Kalay - 4 34 Other stream - 4 98 Dudhsagar stretch is discussed in Cormonem	1 1	2 wet pits and three dumps of which one dump lies in Codli	2 hectares paddy field is affected due to presence of a mine dump
Sigao	Pits - 10 Mine dump - 14	Dudhsagar - 9 51 Other stream - 32 3	4 3	Due to mining activities	35 2 hectares paddy fields are affected
Santona	Pits - 14 Mine dumps-18 B plant - 2 T Pond - 2	Other streams - 13 39	1 5	4 dry pit and 5 dumps	15.1 hectares paddy fields are affected due to two mine dumps

Village Name	Mining Activities	Water bodies and total stretch (km)	Impacted stretch (km)	Contributing factors	Land uses affected due to siltation/effluent discharge/surface run-offs
Cluster IV					
Patiem	Pits - 2	Streams - 36	1.6	None	None
Tudou	Pits - 16 Mine dumps 19	Streams - 27.9	0.94	2 dumps and 1 wet pit	None
Portem	Pits - 8 Mine dumps - 2	Streams - 73.4	0.3	3 dry pits and 1 dump	None
Bati	Pits - 39 Mine dumps-29	Streams - 36.7	3.5	Mining activities	2 hectares paddy field

Source IRS-IC Satellite Imagery, 1997

Cluster I

Prominent rivers in cluster I are Mandovi, Bicholim and Assonara. A number of small streams and nullahs are tributaries to these rivers. In addition there are two lakes Maem and Mulgao. The cluster has 24 pits, 6 benificiation plants and about 91 mine dumps. Of the total river stretch of 125 km in the area about 17.5 km is affected (Table 3 18) In the impacted stretch, settlements are spread over 2 4 km. In addition, about 88 hectares of paddy fields are receiving silt loads either due to their close proximity to the mine dumps or due to their presence along the impacted stretch. The worst affected villages are *Bicholim*, *Carapur* and *Adwalpale*

Cluster II

The major rivers are Madei, Sanquelim (also called Valvet river) and Mandovi. Madei river after joining Khandepar near Pale village becomes Mandovi river Other minor rivers in this cluster are Arvalem and Velgeum river. A number of streams and nullahs are tributaries to these rivers Prominent nullahs are Kudne, Dhonkal and Sonshi. The average annual rainfall of the area is 2500-3000 mm There are about 60 pits, 141 mine dumps, 12 benificiation plants and 9 stock yards in the area. The mining activities and overburden is concentrated along the Sonshi nullah (Figure 3.32) which carries most of the silts of mined waste to the river Kudne

Total stretch of rivers in cluster II is about 98 km of which 43 km stretch is impacted due to mining activities (Table 3.18). Of the impacted stretch, settlements are spread over 3 km stretch 113 hectares of paddy fields are receiving silts due to the mining activities The worst affected villages are *Cotombi, Pissurlem, Maulingum South II* and *Velguem*

Cluster III

In this cluster, two prominent rivers are Khandepar/Dudhsagar and Kalay which is meeting the former in Codli village in close proximity to mining activity Iron ore is transported through jetty located at Zuari river near Sanvordem. The area is drained by a number of perennial and non-perennial streams having a total stretch length of 640 km out of which about 36 5 km stretch length is impacted (Table 3.18). Of the impacted stretch, settlements are along the 1 6 km stretch length These may be dependent on the rivers for their needs 126 hectares of paddy crops are receiving silts either due to their close proximity to the mine dumps or due to their presence near the impacted stretch The worst affected villages are *Codli, Sigao Santona* and *Sanvordem*

Cluster IV

This cluster is rich in water resources having a total stream length of 174 km. The mining activities are concentrated mainly in Tudou and Bati village The total impacted stretch length of streams is 6.3 km. The impacts on water bodies due to mining activities is summarized in Table 3 18.

Table 3.18. Summary of impacts on water bodies due to mining activities

	Total length of rivers (km)	Impacted stretch length (km)	Impacted stretch length along the settlements (km)	Total paddy fields affected (Hectares)	Worst affected villages
Cluster I	125	17 5	2.4	88 5	Bicholim, Carapur & Adwalpale
Cluster II	98 5	43 4	3 1	113	Cotombi, Pissurlem, Maulin South II & Velguem
Cluster III	640	36 5	1.6	126	Codli, Sigao, Santona & Sancordem
Cluster IV	174	6 3	Nil	0 5	Bati

Measures adopted by companies to control water pollution

Many of the companies have been adopting various measures to limit the extent of silt flow into the natural streams. Broadly these measures are as follows:

- Water pumped from working pits pass through settling tanks, check dams before being released to the natural water courses (See Photo 12).
- Treatment with lime for settling of solids in the water collection chambers and settling ponds.
- Incorporation of thickeners in the beneficiation plants to receive hydro clone overflow for settlement and to recover water for re-circulation to the plants.
- Construction of tailings ponds to receive tailings and recovery of water.
- Construction of laterite walls along the periphery of dumps.
- To minimize run off from dumps, contour drains are made and trees are planted on slopes.
- Garland drains are constructed in few mines.
- Number of laterite arresters are constructed in the drainage channel for arresting slime (See Photo 12)
- Oil and grease traps and settling tanks have been provided in one mine to control effluent from workshop and vehicle service depots.

Mine-wise details of water management practices adopted by the companies in clusters II and III are given in Table 3.19

Table 3.19. Wastewater management practices of mines

Name of the mine	Village name	Receiving water body	Wastewater discharge	Water management practices	Comments
Pissurlem	Pissurlem	Dhonkal nullah which joins Mandovi river	Surface runoff has high turbidity. Pit water at final discharge point has turbidity around 1200 NTU and SS around 1264 mg/l	1. Silts in overburden washoffs is controlled/ arrested by a series of two laterite bunds 2. Pit water discharge channel has three laterite bunds in series	The control measures are ineffective in rainy seasons
Deulem	Pissurlem	Dhonkal nullah	Total quantity of water being pumped is about 3.3 Mld	Not available	–
Sonshi mine	Sonshi	Sonshi nullah	Total quantity of water being pumped is about 4.56 Mld SS conc. in pit water = 12 - 3840 mg/l SS conc. in dump runoffs = 4212 mg/l	Not available	Proper measures are needed to control the solids concentration
Sam Donomina	Sonshi	Sonshi nullah	SS conc. of pit water = 90 -2000 mg/l	Pit water is supplied to the villagers for irrigation without the control of silts	Pit water should be treated before discharge
Cudnem	Cudnem	Nullah	Huge quantity of water is being pumped out SS conc. in dump runoffs is 374 mg/l	No adequate provisions to contain the silts	The mine needs to take adequate measures to contain the solids in water
Dignem	Sonshi	No water body nearby	Dump runoff has high concentration of solids. Mine is working above water table therefore pit water is discharged only after monsoon	Not available	Silt arresters for dump runoffs is needed
Surla-Sonshi	Surla	Sonshi nullah	Pit water has fairly good quality	Mine rejects and overburden are dumped near the Sonshi nullah. Also there are no provisions to treat pit water before discharge	Serious measures are needed to prevent high silt load in runoffs from the dumps
Velguem Surla	Surla	Sonshi nullah	SS conc. in pit water = 6 to 124 mg/l	Pit water is used in paddy crops. Huge dumps are located outside the lease in south from where runoffs goes to the downhill paddy fields	Adequate provisions should be made to contain the silts in runoffs

Name of the mine	Village name	Receiving water body	Wastewater discharge	Water management practices	Comments
Sanquelim	Maulinguem South II	Valvoi Gaonthana	SS conc at final discharge point is 644 mg/l	Pit water passes through a settling tank	The settling tank is not very effective to contain the solids
Matta-E-Dando	Valguem	Harvalem river	Overflow of settling tank has SS conc of 40 - 5322 mg/l	Mine is working above water table Rain water is pumped to a settling tank and then passes through a series of cross bunds Old dumps on the banks of river Harvalem are well stabilized	The settling tank and filter bunds needs upgradation.
Gurmolem	Pissurlem	Harvalem river	Pit water has fairly good quality	Not available	–
Pale and Chowgule Co. Ltd	Pale	Madei river	Water is pumped at the rate of 8 2Mld SS conc of pit water is 60-10374mg/l SS conc of water near paddy fields is 956-16324 mg/l	Some amount of pit water is used for irrigation after passing through a bund and the remaining is discharged to the stream	The controls measures to reduce the silts are not adequate
Salitho Ores Ltd	Pale	Madei river	Water pumping rate is about 6 6 Mld SS conc in pit water is 2 - 738 mg/l	Not available	–
Bandekar & Bros. Pvt Ltd	Pale	Madei river	High SS concentration	Silt arresters are erected in the drain channel A parapet wall has been erected to arrest silts in the washoffs from dumps	The control measures are not very effective
Amona beneficiation plant	Amona	Mandovi	The tail water discharged in Mandovi has SS conc of 1472-2676 mg/l In winters, the SS conc is much higher	Water of Mandovi river is used in the plant Tailings are discharged to a tailing pond from where the water goes back into the river	The tailings pond effluent should be recycled in the beneficiation plant
Vagus benificiation plant	Colombi	Mandovi	SS conc of seepage water is 2 - 18 mg/l and dissolved solids concentration is 3806 - 6754 mg/l	About 0 3 million tons of tailings are produced annually which after thickening is sent to a tailing pond The capacity of the tailing pond will last for 14 years	The seepage water of tailing ponds has high conc of TDS Therefore, seepage water should be recycled
Codli	Codli	Khandepar	SS conc in water samples from pit water, benificiation plant, and tailing ponds are high	Water is recycled for its use in Benificiation plant	Good practice

Name of the mine	Village name	Receiving water body	Wastewater discharge	Water management practices	Comments
Kirlapale mine	Santona	Kalay	Nullah originating from waste dumps has high conc of SS	The Nullah has 4 laterite bunds in series to arrest silts but is observed to be ineffective	The provision for arresting silts needs improvement
Cuddegal mine	NA	NA	The tailing water sample measured near mine boundary has high conc of SS	Seepage water of tailing pond passed through two bunds of settling tank and also filtered through two laterite bunds	The filtering arrangement of slime arrester erected across the drain channel needs improvement
Kalay mine	Santona	Kalay	Nullah water before joining Kaley river has high conc of SS	Six silt arresters/Laterite bunds are erected across the channel	The filtering arrangement needs improvement
Costi	Costi	Kalay	High conc of SS in water samples flowing into Kalay river	Seven silt arrester are provided in the drain	Filtering arrangements needs improvement.

Source IBM, Nagpur

Opa water works

River Khandepar, flowing through Clusters II and III, is an important source of drinking water supply to Ponda and Tiswadi Talukas. The water treatment plants at Opa (Ponda) with a capacity of 16.25 MGD, draws water from this river. Public Works Department (PWD) which operates and maintains these water treatment plants are facing problem in the filtration unit during monsoons. This is due to high turbidity of the river water during this period. It is anticipated that the cause of the turbidity in the river water is due to the mining operation in the catchment area of Khandepar river. Consequently a committee was formed consisting of officers from PWD, SPCB, Irrigation Department and Department of Mines to inspect the mining operations in the catchment area. The committee had submitted its report and a summary of the findings are given in Table 3.20.

From the information provided by the Opa water works, it is observed that about 1 to 6 mg/l of alum is added to the raw water which is having a pH of 7.5. From our past experience it seems that the given dosage of alum is very low for water having a turbidity of 1500 NTU Therefore, it is recommended that the Jar Tests should be conducted frequently during rainy season to regulate the coagulant dose. Also at pH 7.5 raw water may not be having sufficient alkalinity for the alum to form flocs, necessary for particle settlement. Theoretically, bicarbonate alkalinity requirements with respect to alum dosage is approximately in the ratio of 2 1 Therefore, it is necessary to have the lime dosage also along with the alum These measures in clarification unit will definitely reduce the problems in filtration unit during rainy season It is also recommended that a pilot study should be carried out for the use of horizontal roughing filters as a pretreatment unit during rainy season

Table 3.20. Findings of the inspection report of mines in Khandepar river catchment

Name of the mines	Water management practices	Comments
M/s Sesa Goa; PTI & Soc. Timblo	Tailings from 3 beneficiation plants is pumped into an abandoned mine pit and clear water is recycled. Therefore the beneficiation plant effluent is well controlled. Pit water is being treated with flocculants and the clear water is being pumped into the nearby abandoned mining pit. In the outlet water channel, filter beds are provided to control the silt flow. No adequate measures to prevent the silts in surface washoffs	This washoff water carrying drain needs to be diverted into the nearby mining pit
Vincient Figueiredo	Ore wash water from 2 benificiation plants is being discharged into the tailings pond and thereafter clear water is recycled. Bunds of the tailings pond were not constructed properly and the leaking turbid water is collected in the detention pond. The surplus water from the pond is likely to drain into river. Surface runoffs is causing turbidity in the river	Adequate measures are needed to prevent the silt loads in the surface runoffs
Ramchant Velingkar	Ore wash from the beneficiation plant is let into the tailings pond and the clear water is recycled. The tailings are deposited in the old mining pit. The water from the mining pit is also pumped for use in beneficiation plant. Soil washoft during monsoon is deposited in the canal which is closed during monsoon. The company removes the silt every year from the canal soon after the expiry of monsoons, to enable to operate lift irrigation scheme for rabi crop	Good control of water and tailings In order to control the solid washoff from the dumps, it is necessary to construct laterite wall at the toe of the rejects
Marzook Cadar, R.R. Poinguinkar & B.A. Tude	Ore beneficiation plant is situated close to a nullah which joins the river at Tathodi. The ore washed water is treated and recycled. The sludge is allowed into the tailings pond. Turbid water from the mining pit is directly pumped into the stream which joins the river	No adequate measures were taken to control the flow of wash-offs from the eastern side dump. Therefore, adequate steps are needed to control the flow of mining rejects during monsoon
Ahiliabai Sardesai	Ore-washed water from the beneficiation plant is discharged into the settling pond and thereafter recycled. Additional water for the plant is met from the working mining pit. Pit water is pumped into a settling pond situated at higher elevation. The collected water in the pond is treated with lime. The water is pumped into a drain which joins the river. It was observed that the water is highly turbid	Suitable filter check bunds are required in the drain at suitable intervals
Mineira Nactionale	Ore-wash water from 2 benificiation plant is collected in a tailings pond and clear water is recycled. Additional water is met from the working pits. Pit water is discharged into the natural drain which joins the river. This water is highly turbid	Mine needs to take suitable measures for pit water treatment

Name of the mines	Water management practices	Comments
M/s Fomento	Pit water is discharged into another mining pit through an open channel Check bund has been constructed	Adequate steps are needed for surface runoffs from mine dumps
G H Agarwal	Ore wash water from beneficiation plant is sent to a tailing pond. Water required for beneficiation is met by pit water No adequate measures to control surface run-offs from mine dumps	Suitable measures are needed for mine dumps
Bimco Goa Ltd	Ore wash water from one beneficiation plant is sent to a tailings pond Beneficiation uses pit water The surface washoff water is controlled to a great extent by providing settling ponds and filter beds	Good practice

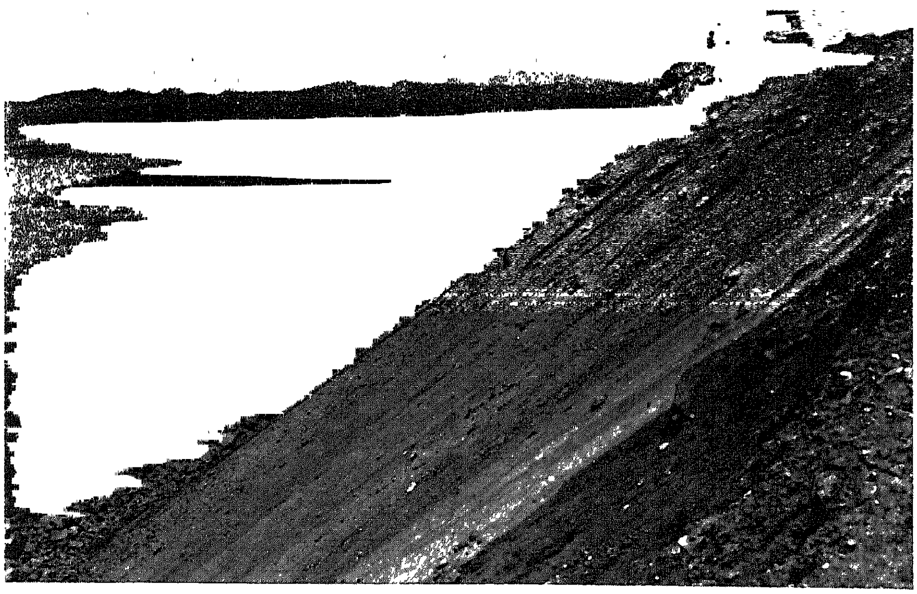


Photo No. 1 Steep dump slope: need to ensure terrace dumping

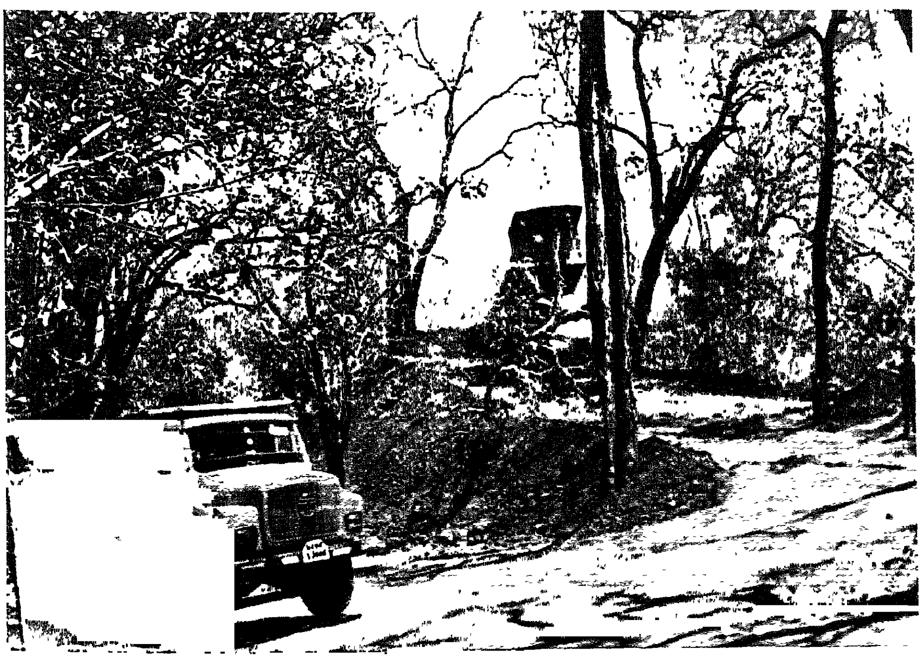


Photo No. 2 Unplanned dump affecting forest area

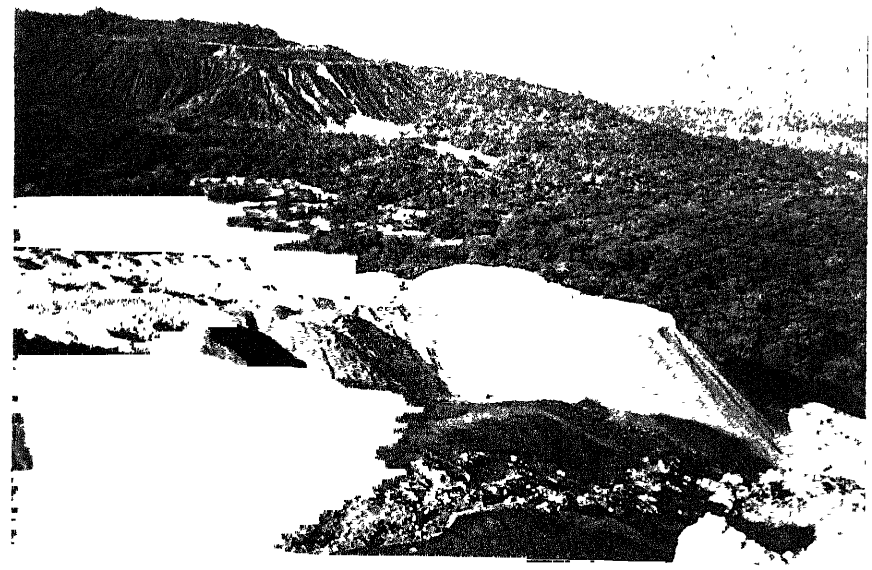


Photo No. 3 Steep dump slope - major cause for silt runoff

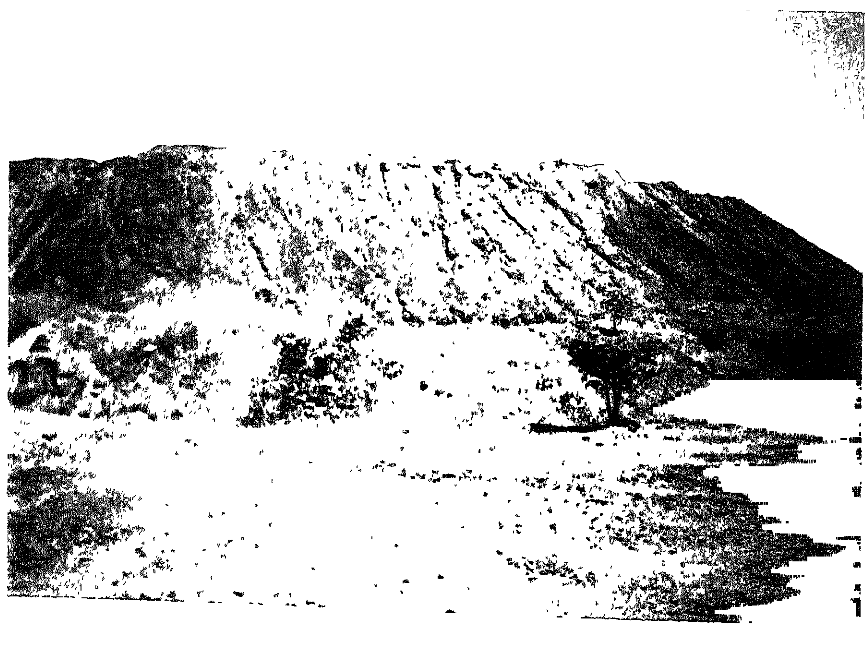


Photo No. 4 Unmanaged dump with rills and gullies formed due to rainfall



Photo No. 5 Silt deposition in agricultural field



Photo No. 6 Wide and deep cracks in silted agricultural fields



Photo No. 7 Ore loaded uncovered trucks: major source of dust pollution

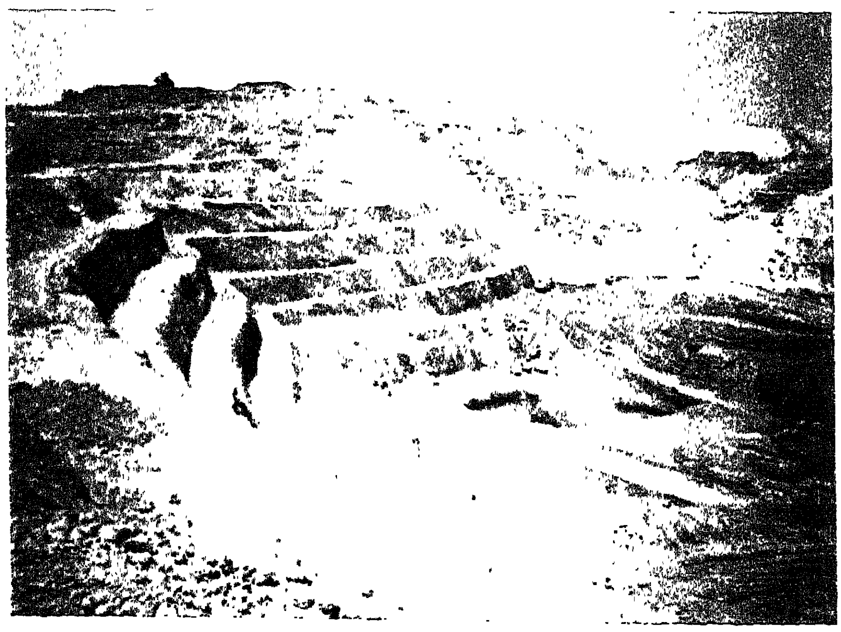


Photo No. 8 Steep benches formed during mining



Photo No. 9 Pit water in operating mine

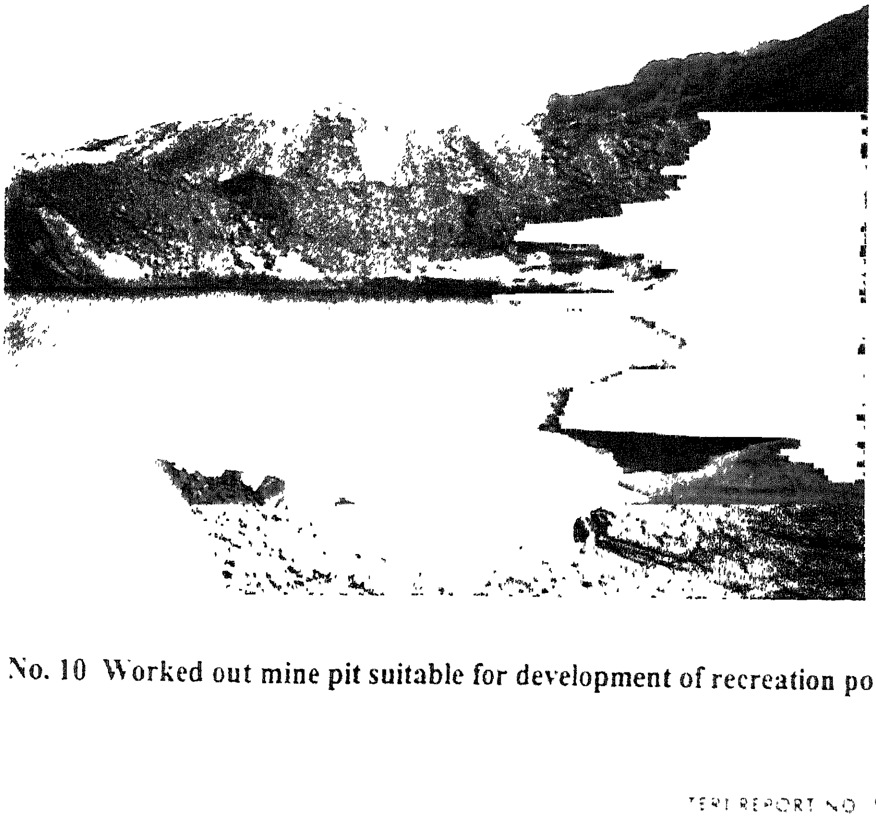


Photo No. 10 Worked out mine pit suitable for development of recreation pond



Photo No. 11 Impacted nallah due to mine water discharge



Photo No. 12 Laterite filter wall to arrest silts in runoff

Ground water quality in wells surrounding the mines

The quality of water in some wells surrounding the mines is presented in Table 3.21. The well water has bacterial contamination and therefore needs disinfection before use

Table 3.21. Groundwater quality surrounding the mines

Cluster	Parameters							
	SS mg/l	TDS mg/l	pH	BOD mg/l	COD mg/l	Chloride mg/l	Sulphate mg l	MPN
I	0 - 38	62 3 -490	6 4 - 7	0 57 - 1 1	1 - 27	13 6 - 50	0 - 65	>1800
II	0	45 - 72	6 6 - 7 2	1 1 - 1 33	8 6 - 9 6	13 6	4 8 - 11 2	> 1800
III	0 - 260	43 - 55	6 5 - 6 7	0 13 - 0 88	5 33 - 17 33	21 - 23 7	1 9 - 5	26 - 40

Impact of mining on ground water

The mining belt has two proved aquifer horizons, namely the top laterite layer and the powdery iron ore formations at depth The top layer with laterite cover is quite extensive in the area and even though mining activities have denuded much of these areas of laterite cover, still some areas are left which have laterite cover. Here the water is in the form of a parched water table with or without any confined pressure.

The friable powdery iron ore at depth are highly porous, permeable and are completely saturated with water During mining, these ore bodies (aquifers) are exposed and water in them gushes into the mine pits under pressure. There are a number of mines which are presently working below the water table and this has led to a continuous dewatering of these ore bodies (See Photo 9) This belt is spread across a strike length of 50 km with an average width of 1 m and average thickness of 30 m. Considering 35% yield, the total quantity of water likely to be confined to this area alone is expected to be about 525 Mcm It is good quality potable water and if harnessed properly can meet the demands of the surrounding villages. The present practice is that the mine water is simply pumped out and allowed to follow the natural topography

One vexed issue is the alleged impact that mining activity is having on local shallow aquifers Reports such as that of Nayak (1994) etc refer to this impact However this aspect has not been systematically examined or studied There are essentially two aspects to the problem·

- The impact that laterite removal has on the recharging capacity of the aquifer.
- The impact of pumping out of pit water.

Hydrogeological investigation

To evaluate and confirm the extent of these impacts, a systematic ground water investigation survey was taken up by a hydrogeologist in the Kudne river catchment areas which falls in Cluster II and includes important mining villages of this cluster. This is a small but representative water shed in the mining belt of North Goa, where there is intense mining activity taking place. Observation well network was established in the area and all the relevant data were collected during the field session in April, 1997. The experiment involved 46 observations wells in the Kudne river catchment area. The data was subjected to analysis using computer aided techniques. Interpretation of the results show that mining impacts on surface as well as ground water regimes are significant The results of the experiment and the findings are presented in summary form. A report on the details of the study is being submitted separately.

The Kudne river is a tributary of Valeont river both of which join Mandovi river south of Sanquelim The Kudne river forms a sub-catchment of Mandovi river. The area is located mainly in Bicholim taluka and partly in Sattari taluka of North Goa district. The area can be located on survey of India toposheet numbers. 48 I/2/3 and 48 E/14/6 of 1·25000 scale The approximate latitude and longitude are 15°30' to 15° 35' and 74° to 74°6' respectively The total area of the catchment is about 4325 hectares. The state highway running between Sanquelim in the west and Valpoi in the east divides the catchment into two equal halves Incidentally the southern half of the catchment forms the mining belt of the area. All the mining activities are confined to this southern part. The main settlement areas are Harvale, Onda, Pissurlem, Cudnem, Salili, Bhuipal and Gavthan. Figure 3 38 shows the location of these observation wells.

But for the mining belt, most part of the area is thickly vegetated and the area receives an annual rainfall of about 3750 mm mainly from south-west monsoon during June to September The area is marked by flat as well as hilly terrains. The topographic elevations range from less than 10m in the western part near Kudne-Mandovi river mouth to about 618m in the north-eastern corner The original topography of the southern half of the catchment is totally altered due to mining activities Cultivation, mining and industrial activities form the major occupation of the local population. Cashew and coconut are the major cash crops of the area

The information gathered from each well include; well depth, diameter, height of measuring point (m.p) above ground, elevation of m.p. above m s l , well owner, age of the well, location, water quality, water use purpose, well water level below m.p., water recuperation level after rains, mining impacts on well water levels and water quality, well yield, water supply source to village other than wells etc. The wells were then transferred on the 1:25000 scale toposheet of survey of India along with identification number. Annexure 3.10 gives of all the 46 observation wells established in the area. Annexure 3.11 gives the well details and reduced levels for the observation wells.

Estimation of rainfall recharge to ground water and groundwater pumping

The main source of recharge to ground water regime is the rainfall. For computation of the above quantities the surface water-divide was demarcated from where all water converges to the outlet point in the catchment. The area of the present catchment is found to be about 4325 hectares of which nearly 47% is under mining belt represented by major mines around Pissurlem, Sonshi, and Kudne. The long-term annual average rainfall is estimated to be about 3750mm (3.75m) Therefore the volume of rainfall on the catchment works out to be 16,218 hectare-metres (1 hectare-metre = 10,000 cubic metres). For estimation of the recharge to ground the area has been classified into two parts. On the northern part of the catchment 5% rainfall recharge rate and in the southern part consisting of mining belt, 10% rainfall recharge rate have been assigned (these values are based from the infiltration studies on the neighbouring catchment and the lateritic terrains of Goa by Chachadi, 1997). Therefore;

i) Recharge (Q in ha-m) in non-mining belt:
= Area (ha) x Recharge rate (%fraction)
= 2294 x 0 1875
= 430 hectare-metres

ii) Recharge (Q in ha-m) in mining belt
= 2031 x 0 375
= 761 hectare-metres

Total recharge to ground therefore, would be about 1192 ha-m. Besides unconfined shallow aquifers, the mining belt in the area also consist of confined to semi-confined aquifers (aquifers which are having water under pressure due to confining impervious clay layers on top and bottom) having an average aggregate thickness of about 60metres. These confined aquifers get recharged from lateral migration and slow percolation from top unconfined aquifers The volume of ground water in these confined aquifers which are incidentally made of iron-ore bodies consisting of powdery ore having high porosity and hydraulic conductivity is worked out as follows.

I)	aggregate thickness of the confined aquifers	= 60 m
ii)	storativity (aquifer physical property)	= 0.005
iii)	aggregate width of ore-body in the area	= 800 m
iv)	aggregate length of ore body in the area	= 7000 m

The quantity of storage Q (in cubic-metres) is,

Q = Area (sq.m) x Storativity (fr) x Thickness of Aquifer (ore body)(m)
[7000 x 800] x 0.005 x 60
1680000 or 168 ha-m.

This is about 15% of the storage in the top unconfined aquifer. It should be noted here

that the shallow unconfined and deep confined (semi-confined) aquifers cannot be treated as separate entities as they are interlinked at some point and hence exchange of ground water takes place vertically. Any mine pit penetrating through the ground in this area has to cut across both the aquifers and hence ground water has to come to pit both from shallow unconfined and deep confined layers. However, at some places local clay barriers have resulted in holding the shallow aquifer water in isolation without allowing the water levels to dropdown due to pit dewatering. The typical example could be the area around Kudne, but on a long run this may change. The total quantity of ground water in storage available in the area is the sum of shallow and deep aquifer storages i.e. about 1360 ha m.

In the present study, due to data constraints this experiment had to rely on data supplied from just three of the mines one each in Kudne, Pissurlem, and Sonshi area For these three mines, the annual ground water pumpage works out to be about 610 hectare-metres which is about 44% of total ground water storage volume (1400 ha-m) estimated for the present catchment. Therefore the total volume of ground water pumpage from all the mines will be much higher.

Constructing groundwater flow lines

In the present study computer assisted flow net sketching has been adopted using "SURFER" package of Golden Software Inc. A flow net constitutes a sketched representation of the flow paths taken by water molecules in moving through the subsurface. The "grid" of a flow net is comprised of flow-lines (idealized paths followed by water molecules in moving from positions of heigh hydraulic head to those of lower head represented by smooth curves at right angles to equipotential lines) and equipotential lines (lines along which the hydraulic head is equal). Flow net is a very powerful analytical tool for studying the ground water behaviour.

Figure 3.39 and 3.40 are the contour plots of the water table elevation above msl Figure 3 39 and 3.40 is plotted assuming mines do not exist Contour maps constructed based on these flow lines show that the general flow of ground water is towards west and southwest directions The ground water table gradients are gentle in most part of the area except around Kudne in the western part Three ground water mounds (recharge areas, ground water elevation is higher here than surroundings) are noticed, one in the Salili area in north-east corner, second around Pissurlem village and the third around Sonshi area from where ground water flow-lines radiate outward to other areas. The ground water troughs (discharge areas, ground water elevation here are lower than the surroundings) around Oonda and Kudne-Gavthan area indicate heavy ground water withdrawals. The steep ground water gradients in the Kudne area indicate heavy to very heavy pumping from ground water. In Figure 3 40 the working mines around Pissurlem and Kudne have been taken into consideration for plotting the water-table contours. The water-table is considered to be at the bottom level of the mine pits. The mine pits are assumed to be at sea level but some of the mines are below sea level

particularly in the Kudne area as reported As seen in the map the Salili and Sonshi areas still remain as major ground water recharge areas whereas the ground water mound at Pissurlem has turned into a ground water trough towards which all the ground water flow lines are converging, with steep gradients indicating heavy withdrawals from ground water Similarly the intensity of the trough at Kudne-Gavthan area has increased. The map clearly shows the mining belt characterized by steep gradients of ground water-table and ground water troughs except at Sonshi The existence of a recharge area at Sonshi could be due to mine water reabsorption in the ground along the Sonshi-nallah The ground water trough at Onda could be due to heavy groundwater pumping for non-mining purposes as there are no mines nearby

Figure 3.38. Location map showing observation well network

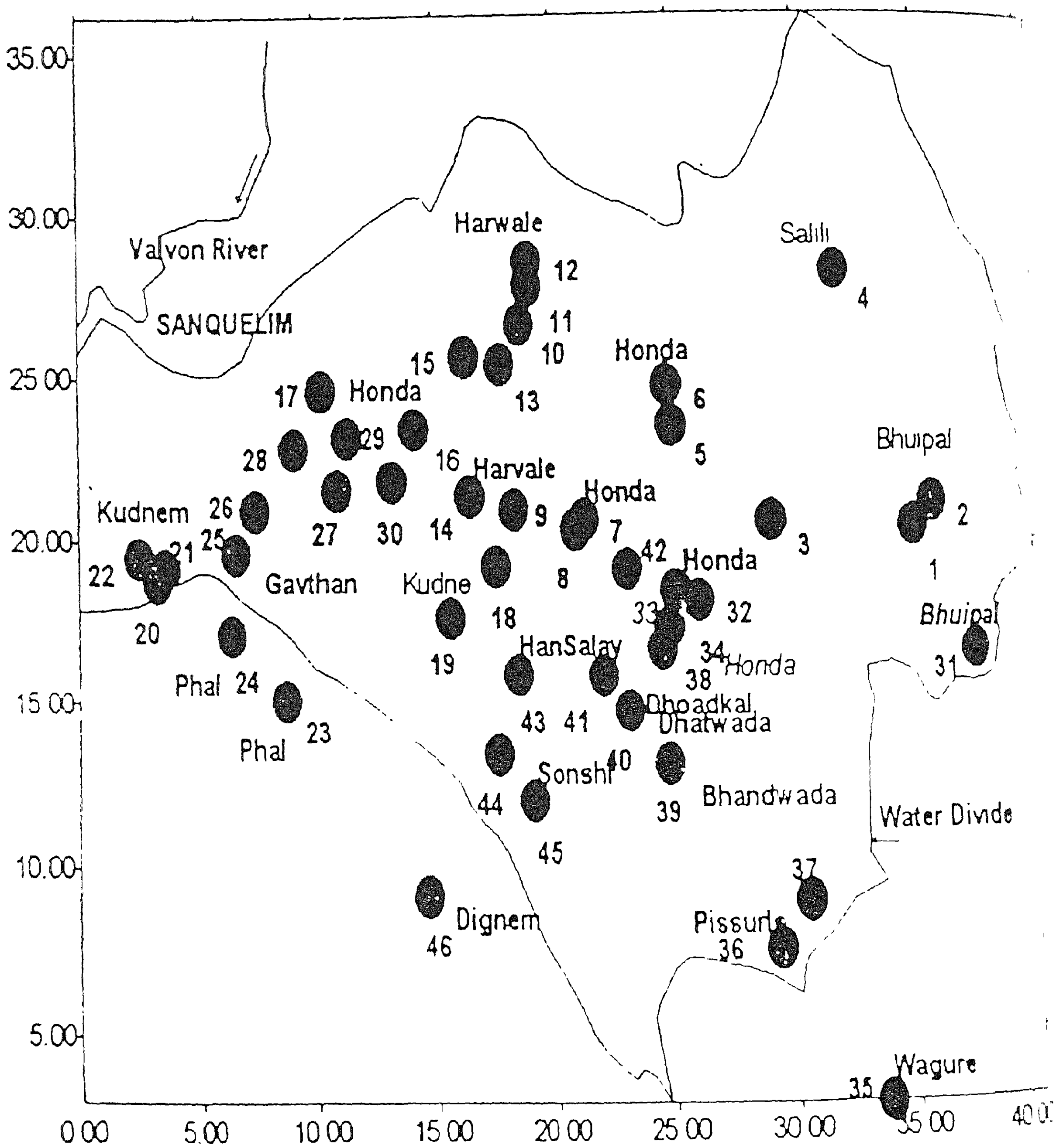


Figure 3.39. Water-table elevation map above msl (April, 1997)
(Contours are in meters)
[The mine pit water-levels not considered in this map]

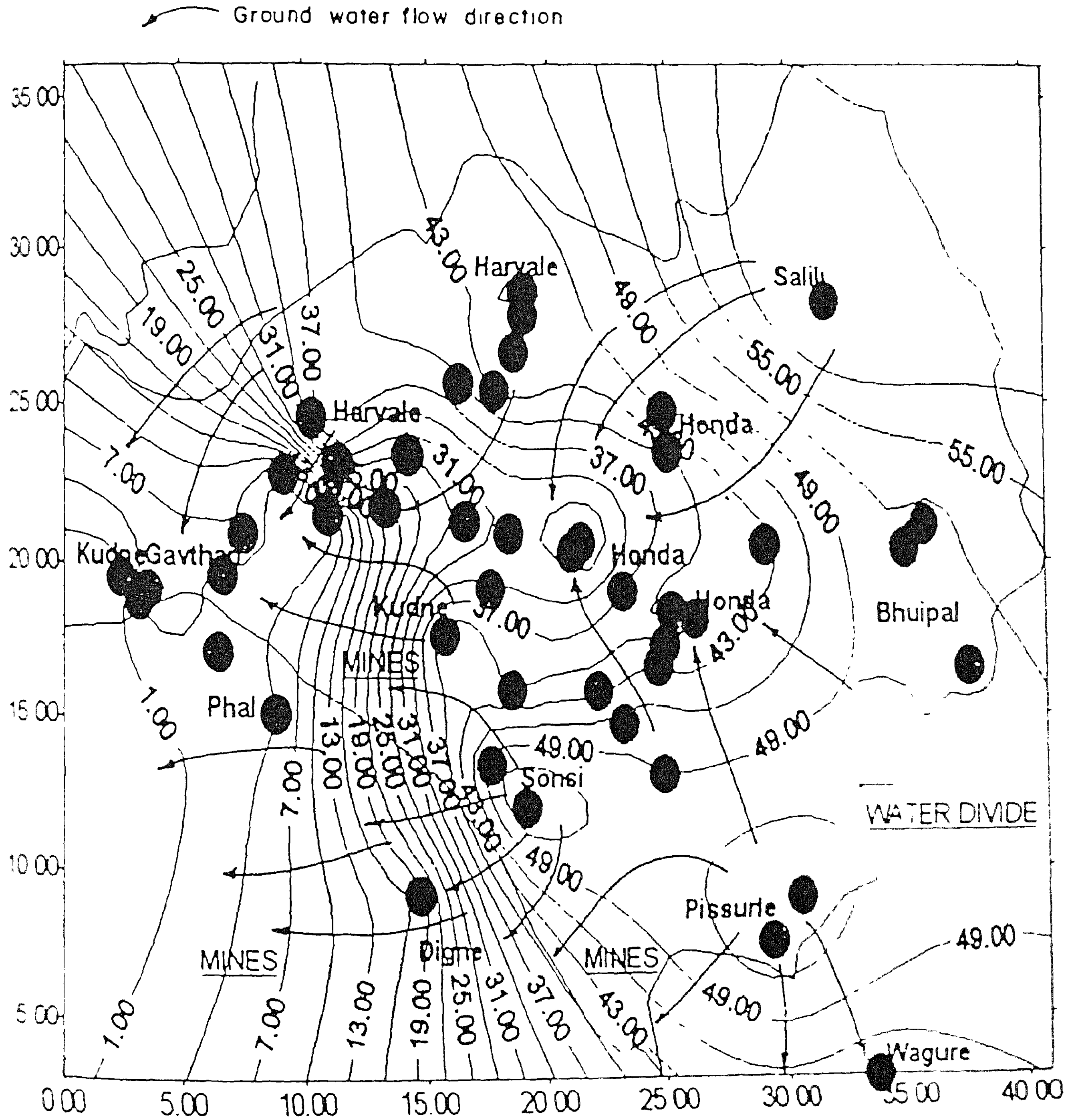
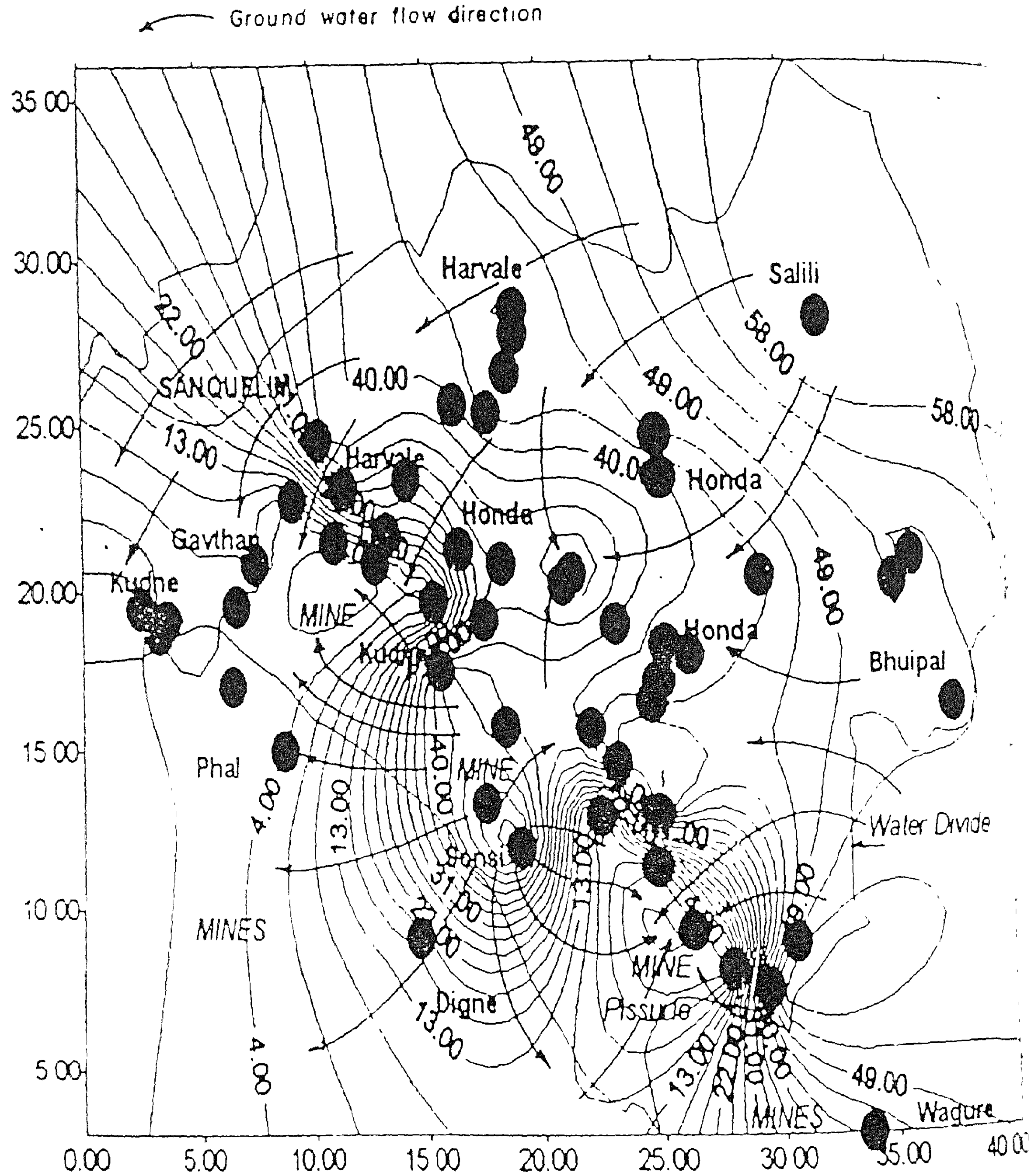


Figure 3.40. Water-table elevation map considering water levels in the mine pits at Pissurlem and Kudne to be at Zero msl
(Contours are in metres w.r.t. msl)



Impact of mine-dewatering on river base-flow

Under natural conditions the rain water percolates down into soil and slowly emerges at the stream banks as lean-period flow or base-flow. As most of this flow emerges after the rainy season this forms an important resource for various purposes. In Goa most of the mines are located in close proximity of the rivers. When ground water from mine pits which are far below the river bed level are pumped the base-flow getting into the river is cutoff besides the river bed itself may go dry if the mine is very close by. Mining in Goa has not only diverted the base-flow component from rivers but the nearby surface water bodies, springs and even soil moisture in nearby agricultural lands have been depleted.

The study conducted on this small but representative catchment has brought out the following.

- The ground water being pumped from the mine pits comes both from shallow unconfined and deep confined aquifer layers
- The shallow aquifer water levels are affected due to mining and this phenomena is site specific and time specific. For example, the case of drying of shallow open wells around Pissurlem area is not witnessed around Kudne mines as these mines are located at the receiving end of the ground water (all ground water is flowing towards these areas) besides having local ground water barriers which are isolating the shallow aquifer water from being let into the mine pits. However, with passing of time and the spread of mining activity this may change. On the other hand mines around Pissurlem are located at the surface water divide of the catchment and therefore at the loosing end of ground water (ground water flows away from these points) and hence magnifying these effects.
- The linkage between mine pit water and the aquifer water is more than evident from the study, however at some locations it is yet to be felt
- The preliminary study shows about 1400 hectare-metres of ground water storage in the area, this values however can be refined based on further data collection
- The mines working close to the western parts of the area near Kudne area might get affected due to salt water entry into the mine pits in due course of time, therefore efforts should be made to keep this salt water within permissible limits from mines (studies are needed to ascertain the extent of salt water impact near these mines).

Summary

In this chapter, the status of the environment as of 1996/97 in each village within the study area has been discussed The impacts on land, air & water quality have been quantified. The impacts vary from village to village depending on the level of mining and associated activities in the area. For air quality, an air quality index has been generated for the mining villages. The population in each village has been obtained from the census data and the population density has been worked out. The socio-economic conditions in each village has

been discussed in chapter 2 and a societal index developed. Taking both environmental impacts and socio-economic conditions, a total impact index (TII) has been derived for each village. The total impact index is the summation of individual indices for air, land, water and socio-economic conditions. The indices are categorized as follows: Highly affected-4; moderately affected-3; less affected-2; and not affected-1.

The parameters considered for air Index are population density and air quality. For water Index, impacted stretch of stream/river/nallah and land area affected due to siltation in each village has been taken. For land index, the percentage of land area under mining and related activities in each village has been taken as the criteria and socio-economic is based on activity, organization and resilience of the village population. The village-wise details are given in Table 3 21. Figures 3 41 to 3.44 show the villages affected cluster-wise due to mining activities.

Table 3.21. Villages affected by mining activities

Villages	Affected by mining activities				
	Land index[1]	Air index[2]	Water index[3]	Social index[4]	Total impact index (TII)
Cluster I					
Adwalpale	2	1	1	1	5
Sirigao	4	4	4	3	15
Mulgao	3	2	1	2	8
Sarvona	1	1	1	1	4
Maem	2	1	3	1	7
Carapur	1	1	1	1	4
Piligao	2	1	1	1	5
Aturli	1	1	1	1	4
Vainguinim	1	1	1	1	4
Ona	1	1	1	2	5
Lamgao	4	1	1	2	8
Naroa	1	1	1	1	4
Bicholim	2	1	4	1	8
Cluster II					
Cassabe de Sanquelim	1	1	1	1	4
Arvalem	2	2	1	2	7
Cudnem	4	4	1	3	12
Surla	3	2	3	3	11

Velguem	4	4	2	3	13
Pale	3	4	4	3	14
Virdi	1	1	1	1	4
Navelim	2	1	3	1	7
Maulinguim South	3	1	1	1	6
Cotombi	4	1	4	1	10
Amona	2	1	1	1	5
Pissurlem	4	3	2	4	13
Sonshi	4	3	4	3	14
Vaguriem	3	1	1	3	8
Advoi	1	1	1	1	4
Onda	2	2	1	1	6
Vantem	1	1	1	1	4
Birondem	1	1	1	1	4
Codiem	1	1	1	1	4
Ponocem	3	3	4	2	12
Cumarconda	1	1	1	1	4
Cluster III					
Darbandora	2	1	4	4	11
Sancordem	2	1	3	1	7
Sigao	2	1	4	3	10
Sangod	2	1	1	3	7
Carmonem	2	3	2	3	10
Codli	3	3	4	3	13
Bandoli	2	1	1	1	5
Santona	4	3	4	3	14
Calem	2	1	1	1	5
Dudal	2	1	2	1	6
Costi	2	3	3	1	9
Caranguinim	2	1	1	1	5
Camproi	1	1	1	1	4
Muguli	1	1	1	1	4
Camarconda	1	1	1	1	4
Rumbrem	2	1	1	1	5

Sanvordem	2	4	1	1	8
Antoriem	1	1	1	1	4
Moissal	1	1	1	1	4
Cluster IV					
Patiem	1	1	1	4	7
Tudou	3	1	1	4	9
Potrem	1	1	1	1	4
Bati	1	1	3	2	7

1	*Villages affected Land index Mining activities in villages*	*Highly 4 > 20%*	*Moderate 3 10-20%*	*Low 2 < 10%*	*Nil 1 Nil*
2	*Villages affected Air index*	*Highly 4 High population density (> 300) + Poor & bad air quality*	*Moderate 3 Less population density (< 300) + Poor & bad air quality*	*Low 2 High population density (> 300) + Fair air quality*	*Nil 1 Less population density + Good air quality*
3	*Villages affected Water index*	*Highly 4 Impacted stretch (> = 2 km) + Land area affected (> = 10 Ha)*	*Moderate 3 Impacted stretch (> = 2 km) + Land area affected (< 10 Ha)*	*Low 2 Impacted stretch (< 2 km) + Land area affected (< 10 Ha)*	*Nil 1 Nil*
4	*Villages affected Social index Based on activity, organization resilience*	*Highly 4 [illegible]*	*Moderate 3 [illegible]*	*Low 2 [illegible]*	*Nil 1 Non mining*
5	*Villages affected (TIII)*	*Highly [illegible]*	*Moderate [illegible]*	*Low or not [illegible]*	

The highly and moderately affected villages are Highly affected - Sirigao, Cudnem, Surla, Velguem Pale, Pissurlem, Sonshi, Ponocem, Darbandora, Codli and Santona, moderately affected - Mulgao, Maem, Lamgao, Bicholim, Arvalem, Navelim, Maulinguim South, Cotombi, Vaguriem, Onda, Sancordem, Sangod, Cormonem, Costi, Dudal, Sanvordem, Patiem, Tudou and Bati

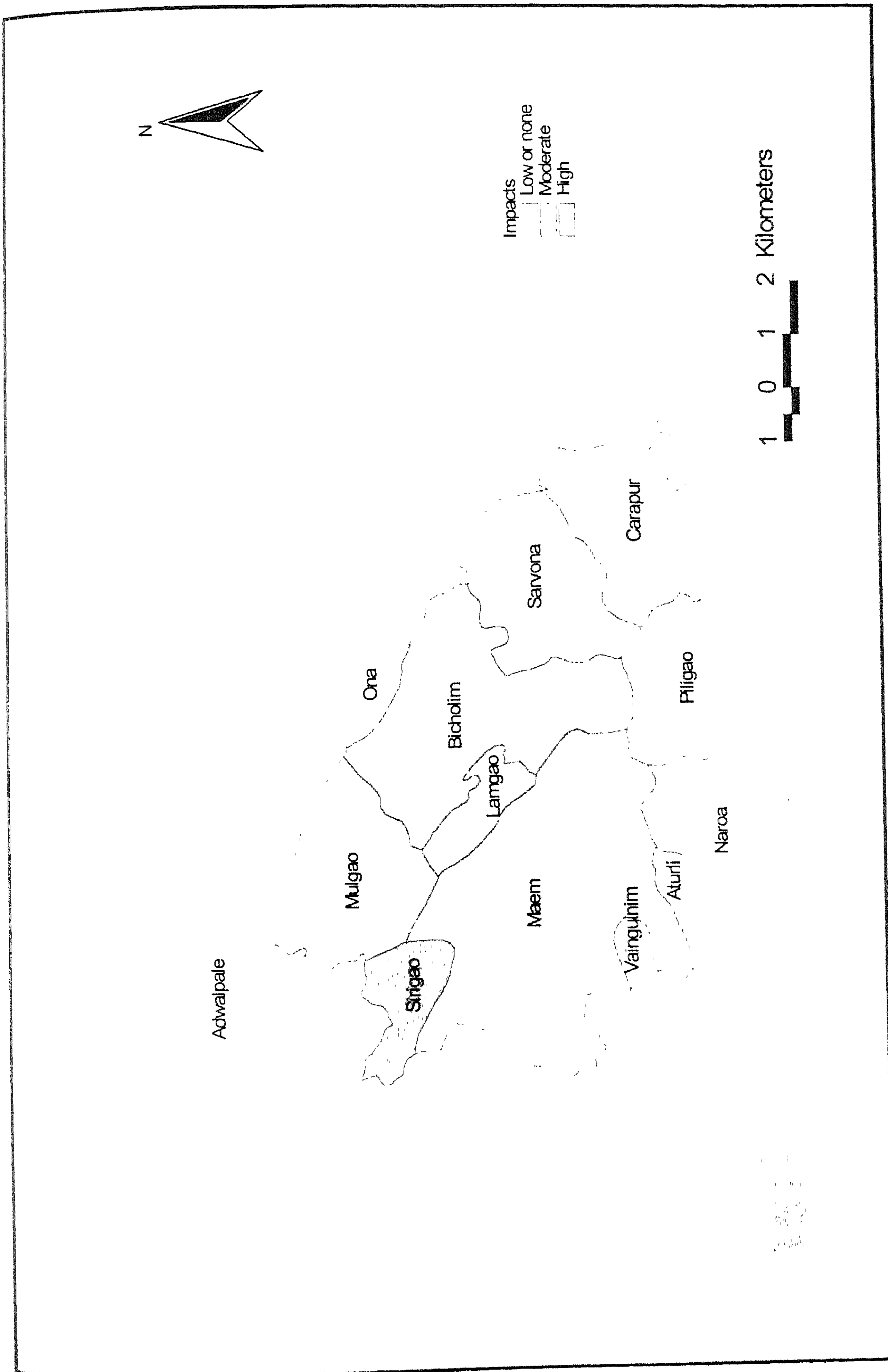


Figure 3. 41 Villages affected by mining activities - cluster I

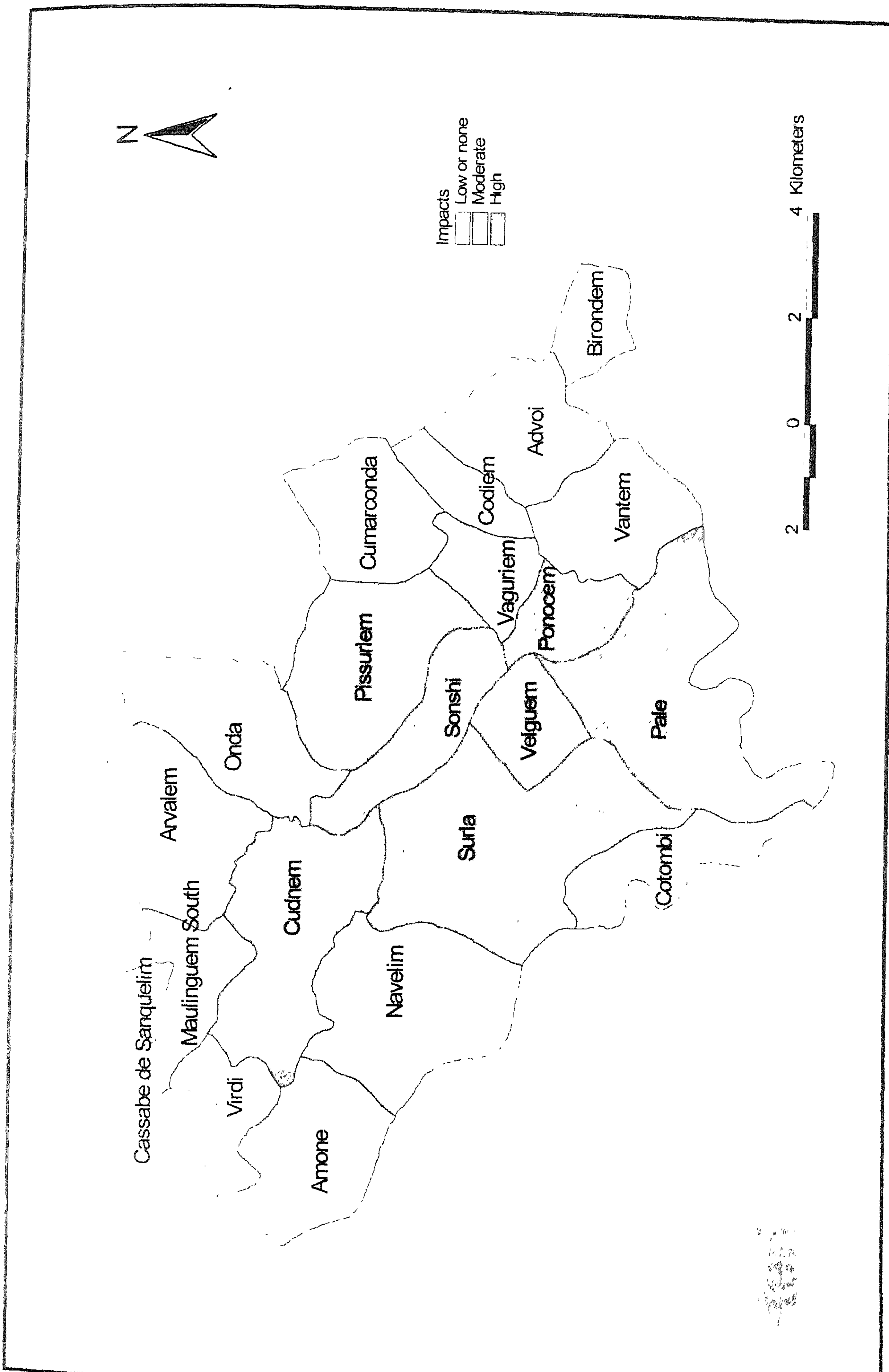


Figure 3. 42 Villages affected by mining activities - cluster II

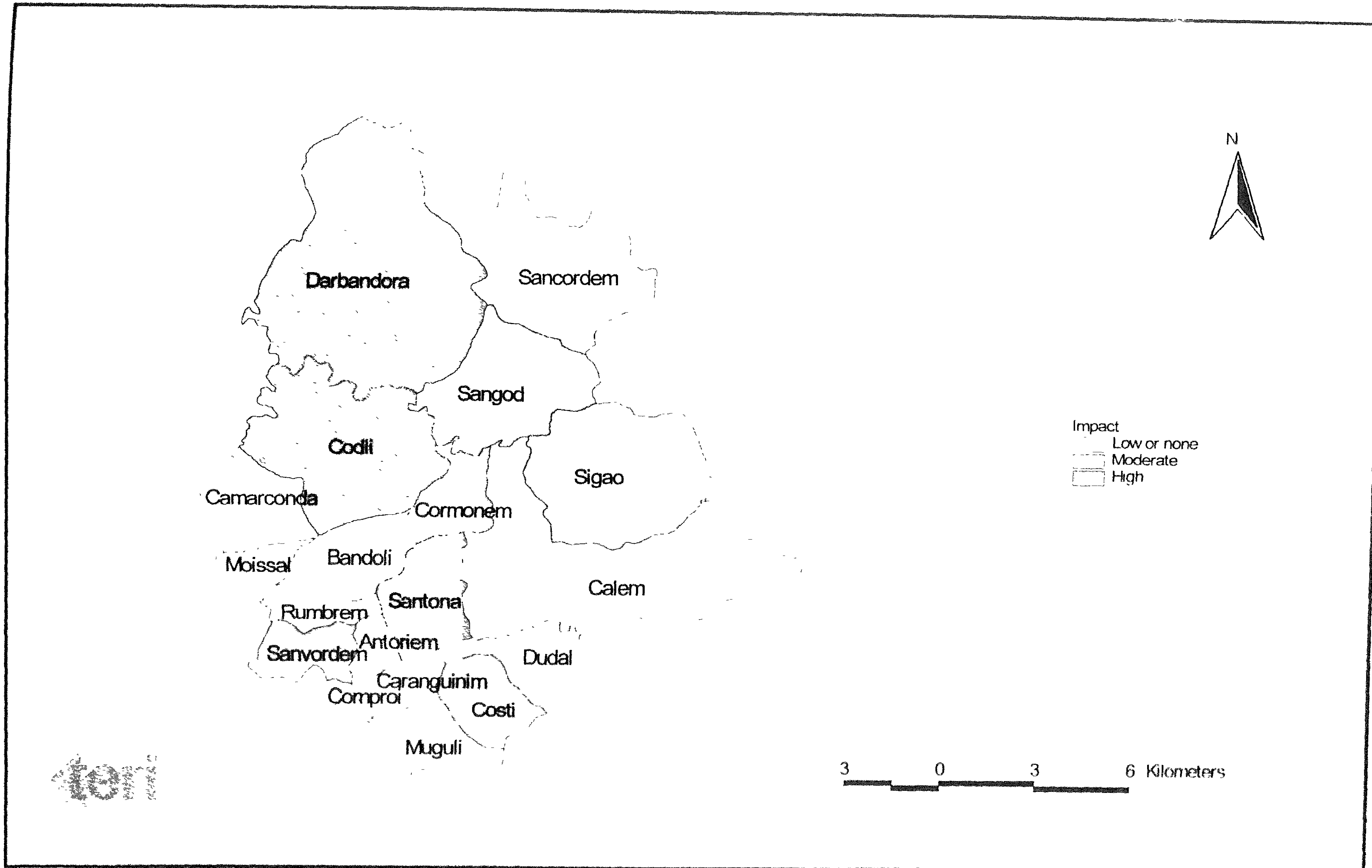


Figure 3. 43 Villages affected by mining activities - cluster III

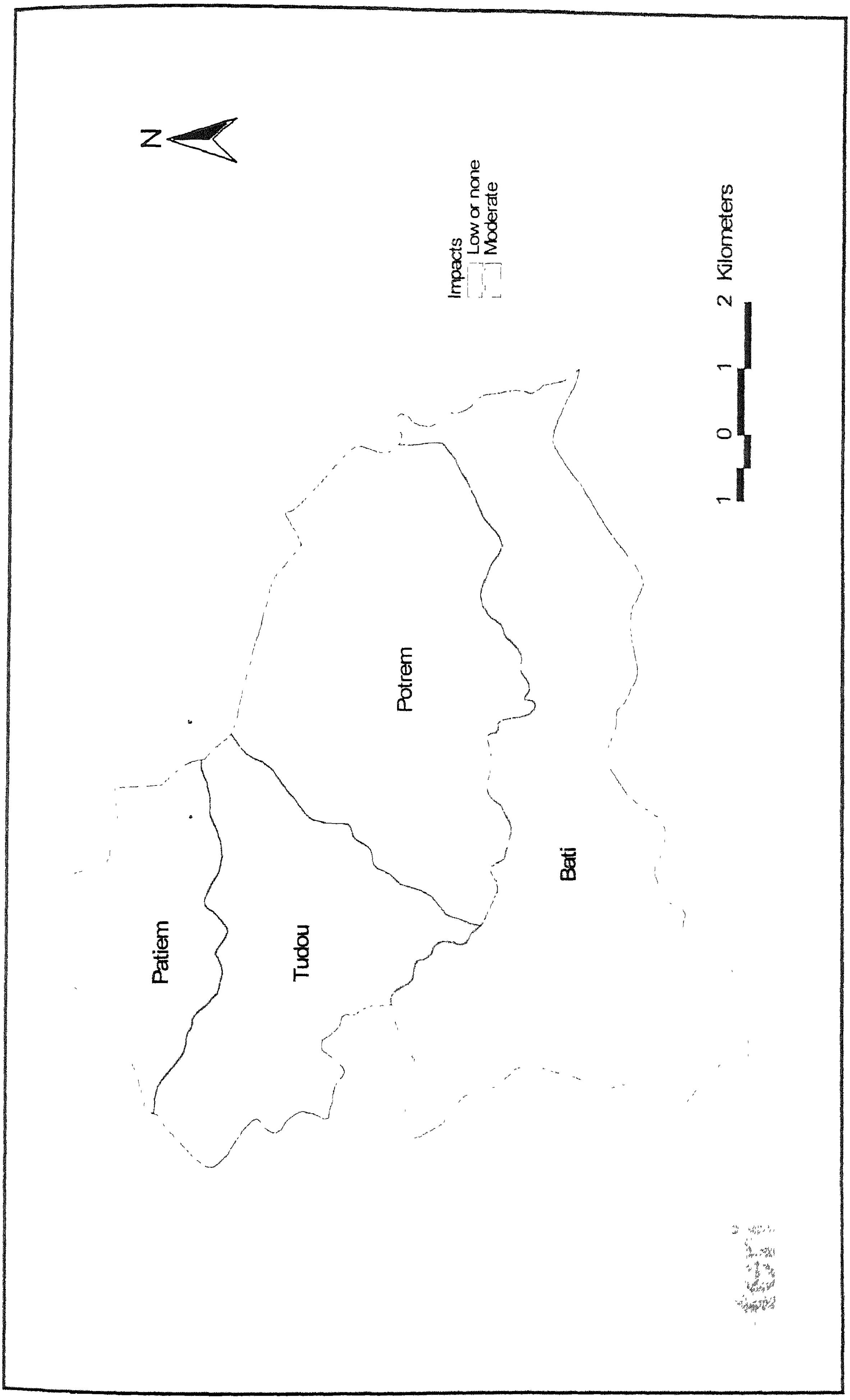


Figure 3.44 Villages affected by mining activities - cluster IV

Annexure 3.1. Month wise rainfall recorded for North Goa (in mm)

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1986	–	–	–	–	9.4	1133.4	695.0	945.4	769.4	23.0	84.3		[illegible]
1987	–	–	–	–	19.7	1184.7	860.3	924.1	229.9	266.6	9.4	81.5	3575.8
1988	–	–	–	–	9.3	687.4	1942.6	1195.1	594.4	34.4	–		[illegible]
1989	–	–	–	2.9	33.8	1325.0	968.3	744.5	423.8	97.5	5.1		[illegible]
1990	–	–	–	–	295.3	974.5	1062.0	1071.5	313.6	293.0	48.8	–	[illegible]
1991	–	–	–	32.3	47.2	866.1	1450.2	855.2	66.3	629	5	–	[illegible]
1992	–	–	–	–	16.9	1230.1	1179.8	914.2	299.1	157.0	16.7		[illegible]
1993	–	–	–	–	57.3	676.2	1353.0	689.6	505.5	554.9	[illegible]	14.4	[illegible]
1994	–	–	–	39.5	17.0	986.9	1488.4	1079.5	294.9	[illegible]	–	–	[illegible]
1995	–	–	–	–	162.3	679.5	1742.8	890.3	371.9	[illegible]	–		[illegible]
													[illegible]

Annexure 3.1b. Month wise rainfall recorded in South Goa (in mm)

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1986	–	–	–	2	5 6	742 0	718 7	1010 0	270 1	4 5	102	-	285[illegible]
1987	–	–	–	9 8	89 8	942 8	984 0	918 1	182 8	301 9	28 4	8 7	34[illegible]
1988	–	–	–	26 5	19 1	846 7	1626 4	1445 5	725 3	78 7	–	–	47[illegible]
1989	-	–	–	–	27 1	1294 6	1077 9	767 8	279 8	163 7	0 8	-	3611
1990	–	-	–	–	271 6	1178 7	1055 5	1077 [illegible]	372 1	159 3	–		41[illegible]
1991	–	–	–	32 9	02 1	777 4	1361 7	788 3	64 5	65 3	10 0	–	320[illegible]
1992	–	–	–		48 5	1219 6	1147 5	1059 5	375 9	106 4	19 8	–	35[illegible]
1993	–	–	–	6 2	52 2	619 7	1570 5	727 6	375 7	273 4	31 [illegible]	31 0	3688
1994	–	–	–	51 4	32 6	1097 9	1445 3	1061 5	176 9	260 1	-	–	412[illegible]
1995	1 9	–	–	2 2	86 7	742 4	1722 9	956 5	206 5	187 9	26 2	–	384[illegible]
													376[illegible]

Annexure 3.2 Village wise land use pattern (based on satellite imaginary - 1997 interpretation) (in hectares)

	Mine pit	Dump	Benefication plant	Tailing pond	Stock yard	Sub total	Mixed Crop	Wet land agriculture	Built up area	Vegetation	Degraded land	Water bodies	Sub total	Total
Cluster1														
Adwalpale	30	17				47	630		15		10		656	702
Sirigao	68	21			14	103	42	101	28		2		174	277
Mulgao	58	19	5			82	520	106	26		23		675	757
Sarvona						0	631	93	10		0		735	735
Maem	52	106	16	-	0	180	1290	252	100		152	18	1813	1993
Carapur						0	652	95	34		63	16	861	861
Piligao		0	5	4	4	13	505	139	10			50	703	716
Aturli						0	58	3			8		69	69
Vainguinim						0	41	19	6		3		69	69
Ona						0	197						197	197
Lamgao	42	16	0			59	101	38	9		4		152	211
Naroa						0	555	113	12		42	74	796	796
Bicholim	6	13	6	5		29	904	67	190		22		1182	1211
Cluster II														
Sanquelim							16		32			0	49	49
Arvalem	8	4				12	489	88	103		26		705	717
Cudnem	142	86	4			231	504	121	36		70	11	741	972

	Mine pit	Dump	Beneficiation plant	Tailing pond	Stock yard	Sub total	Mixed Crop	Wet land agriculture	Built up area	Vegetation	Degraded land	Water bodies	Sub total	Total
Surla	78	88	[illegible]		1	169	801	85	46		361	15	1307	1477
Velguem	62	47				109	82	21	43	5	80		231	339
Pale	135	104	3	11		252	456	57	56	66	347	73	1053	1306
Virdi						0	236	34	2			23	296	296
Navelim	2	0	10	38	35	85	505	111	33		216	57	921	1006
Maulinguim	33	35	2	3		73	275	3	63		0	10	352	425
Colombi	4	3	20	21	50	98	154	85	21		45	66	372	470
Amone		4	24	2	14	44	228	301	37			91	657	701
Pissurlem	128	84	2			214	459	49	11	1	126		646	860
Sonshi	82	105	2			189	174	1	122		17		314	503
Vaguriem	25	6				31	257	0		0	1		258	289
Advoi						0	538	25	5		2	8	578	578
Honda	9	3	0			12	560	65	92		25		742	754
Vantem						0	464	18	2	55	24	22	585	585
Birondem						0	229					20	249	249
Codiem						0	224	21					245	245
Ponocem	9	31				40	198	5	1	49	21		274	314
Cumarconda						0	537	24			1		562	562

	Mine pit	Dump	Beneficiation plant	Tailing pond	Stock yard	Sub total	Mixed Crop	Wet land agriculture	Built up area	Vegetation	Degraded land	Water bodies	Sub total	Total
Cluster III														
Darbamdora	88	80				168	1637	104	19	2287	130		4176	4344
Sancordem	66	20				86	452	35	7	1418	186		2098	2184
Sigao	42	43				85	996	257	25	822	32		2132	2217
Sangod	18	12		2		30	855	112	12	590	18		1587	1617
Cormonem	16	11	1	17		28	417	27		74	4		522	550
Codli	118	127	5	68		250	1397	62	36	321	201		2017	2267
Bandoli	2	12				14	415	31	11	296	18		771	785
Santona	125	91	4	7		220	327	52	8	156	97		640	860
Calem	12	10				22	1160	50	20	2242	21		3493	3515
Dudal	20	9		4		29	443	29	3	203	25		703	732
Costi	16	10	0			26	555	32	10	3	35		635	661
Caranguinim			7	17		7	194	0	3	142			339	346
Comproi						0	113	3	4	10			130	130
Muguli						0	593	14	3	180	1		791	791
Camarconda	2	1				3	610	14	7	148	42		821	824
Rumvrem	6					6	7		8	341	7	22	363	369
Sanvordem	2	2				4	198	15	56	246			514	518
Antoriem	1					1	29		0	197	7		233	234

	Mine pit	Dump	Benefication plant	Tailing pond	Stock yard	Sub total	Mixed Crop	Wet land agriculture	Built up area	Vegetation	Degraded land	Water bodies	Sub total	Total
Moissal						0	108	3	8	160		17	279	279
Cluster IV														
Patiem	4					4	52			808	0		860	864
Todou	78	73				151	555	17	2	714	60		1348	1499
Portrem	7	2				9	220	1	3	2020			2244	2253
Bati	103	81				184	1730	71	21	5573	60		7455	7639

Annexure 3.3 Analysis of samples collected

Sample Site	Physical composition (%)				pH	Total							Available (ppm)	
	C Sand	F Sand	Silt	Clay		N	P	K	Ca	Mg	Na	O.C.	P	K
Along a transit running from dump-top down to agricultural field														
Onda mine														
1.	14.8	80.2	3.1	0.7	6.21	0.031	0.117	0.030	0.276	0.122	0.20	0.32	1.66	23.35
2.	12.6	10.3	2.5	0.2	5.82	0.203	0.210	0.111	0.120	0.207	0.396	1.92	2.02	44.78
3.	29.5	18.9	2.8	0.1	6.20	0.228	0.228	0.227	0.220	0.231	0.550	1.50	2.07	75.85
From worst affected nalas														
Cudnem nala														
4	1.3	84.4	13.2	1.1	6.43	0.069	0.247	0.081	0.030	0.213	0.350	0.94	1.72	38.03
5	2.5	85.8	6.9	4.8	6.64	0.062	0.141	0.076	0.163	0.304	0.133	0.66	1.01	22.11
6	14.1	80.5	4.3	1.1	6.35	0.061	0.164	0.035	0.10	0.55	0.104	0.67	1.45	13.48
Advoi nala														
7	39.7	26.4	3.6	0.05	6.15	0.033	0.193	0.025	0.06	0.27	0.175	0.16	2.03	5.43
8	23.1	3.9	1.5	0.1	6.08	0.036	0.199	0.045	0.020	0.134	0.396	0.42	1.18	3.30

Source: TERI, New Delhi.

1. Northern side of the active dump at Onda mine before the first arrester
2. Northern side of the active dump at Onda mine between 2m before the 2nd arrester and trench
3. Northern side of the active dump at Onda mine virgin field soil 20 m away from the 2nd arrester
4. Silt lifted from the distributory of Kudne nala
5. Agricultural field in Kudne command area
6. Abandoned agricultural field in Kudne command area
7. Abandoned agricultural field in Advoi command area
8. Bed of Advoi nala raised by 2-3 metres

Annexure 3.4. Physico-chemical properties of soil in Bicholim Taluka (MoEF Study)

Sample station	Characteristics								
	pH	Moisture content (%)	Organic carbon (%/g)	Total Nitrogen (mg/g)	Phosphorus Kg/Acre	Manganese (mg/g)	Total iron (mg/g)	Fe^{2+}	Fe^{3+}
Surla	6.6	27.6	0.01	66.4	-	6.7	15.2	558.5	414.0
Maem	5.3	41.9	0.02	63.9	-	1.8	1.0	368.0	1756.0
Mulgao	7.0	36.1	0.03	79.2	-	11.3	0.6	985.0	675.0
Langaon	6.4	21.4	0.02	58.5	0.8	3.2	4.3	365.0	850.0
Dignem	6.0	32.90	0.02	90.3	0.2	0.3	0.7	867.0	483.3
Cubnem	6.7	39.7	0.3	70.2	0.05	2.9	1.1	468.0	684.0
Velguem	6.7	14.3	0.02	48.7	-	7.3	7.5	680.0	596.0
Pilligao	6.03	-	0.01	83.4	-	1.1	25.4	1066.67	2500.0
Sirigao	5.9	16.05	0.02	61.4	0.1	10.03	0.9	470	1260.0
Virdi	5.7	28.4	0.01	66.3	0.3	1.2	0.6	360	890
Navelim	5.1	22.4	0.02	50.4	0.2	6.8	3.9	420	976
Forest area	6.9	42.0	0.7	91.4	0.9	1.3	0.2	250	400
Undisturbed area	5.3	44.6	0.03	70.1	0.1	2.7	0.6	350	2600

Source Project Report on "Effect of mining on microbial ecology of Bicholim Taluka (November 1995)

Annexure 3.5 Analysis of soil samples collected from agricultural feilds and plantations (South Goa)

S No	Parameters	Paddy field east of pit No 3, Codli	Paddy field near Dabal panchyat office	Garden mixed vegetarian, Codli	Paddy field near & west of dump, Codli	Paddy field near & east of dump, Codli	Paddy field near dump, Kirlapal	Garden mixed plantation Cudegal	Paddy field east of Ravalnath pit, Kale	Kaley river mid stream mediterrian seasonal paddy, Kale	Garden mixed plantation, Costi
	Physical properties										
1.	Particle size distribution										
	I) Sand (0 02 - 2 0 mm) %	10 9	22 0	12 6	8 2	48 3	36.5	48 6	52 3	87 5	83 4
	ii) Silt (0 002 - -0 02mm) %	46 3	30 4	26 6	27 8	23 2	37 8	16 6	28 5	8 6	5 8
	iii) Clay (< 0 002 mm) %	42 8	47 6	60 8	64 0	28 5	25 7	36 8	19 2	3 9	10 8
	iv) Texture		Clay	Clay	Clay	Sandy-clay-loam	Loam	Sandy-clay-loam	Sandy-clay-loam	Sand	
2	Moisture retention										
	I) 1/3 bar (%)	34 8	29 6	36 5	37 2	27 6	45 2	30 1	28.7	12 8	15 6
	ii) 15 bar (%)	15 2	16 3	20 1	21 5	14 5	28 7	17 4	18 6	6 5	8 5
3	Permeability (mm/hr)	24	18	17	16	36	34	46	72	94	68
4.	Bulk density (g/cc)	1 5	1 4	1 4	1 4	1 6	1 5	1 6	1 5	1.4	1.7
	Chemical Propertises										
5	pH	5 5	5 3	6 3	5 9	6 0	6 2	6 4	6 2	6 5	6 2
6	Electric conductivity (mS/cm)	392	420	650	654	443	512	692	748	698	764
7	Cation exchange capacity (meq/10)	17 4	24 3	21 8	23 6	15 6	12 9	20 6	14 6	3 2	12 6

S No	Parameters	Paddy field east of pit No 3 Codli	Paddy field near Dabal panchyat office	Garden mixed vegetarian, Codli	Paddy field near & west of dump, Codli	Paddy field near & east of dump, Codli	Paddy field near dump, Kirlapal	Garden mixed plantation Cudegal	Paddy field east of Ravalnath pit, Kale	Kaley river mid stream mediterrian seasonal paddy, Kale	Garden mixed plantation, Costi
8	Exchangeable Ca + Mg (meq 100 g)	3.[illegible]	1.9	1.6	5.5	3.4	2.1	1.7	2.3	0.8	2.8
9	Exchangeable K (meq 100 g)	0.5	0.1	0.1	0.5	0.4	0.4	0.4	0.6	0.1	0.3
10	Organic carbon (%)	1.2	1.3	1.2	1.1	0.9	1.5	0.7	0.8	0.6	0.6
11	Ammonical Nitrogen	0.15	0.16	0.13	0.14	0.08	0.18	0.05	0.08	0.06	0.08
12	Potassium (%)	0.38	0.17	0.32	0.35	0.27	0.45	0.21	0.16	0.18	0.15
13	Phosphorus (%)	0.05	0.04	0.06	0.04	0.05	0.03	0.05	0.04	0.06	0.03

Source: IBM (Mining Research Cell)

Annexure 3.6 Analysis of soils of agricultural fields and plantations (North Goa)

S No	Details on sample location	Mechanical analysis Sand %	Silt %	Clay %	HC %	WHC	Sp gravity	Bulk density	Pore space	Vol Exp	CaCO3	pH (1 2 5)	EC (1 5)	Ex Ca (me/ 100gm)	Ex Mg (me/ 100gm)	Ex Na (me/ 100gm)	Ex K (me/ 100gm)	CEC (me/ 100gm)	Tex
1	Dewalwada Paddy field	45.2	52.4	24.4	25.6	42.0	2.7	1.5	71.6	4.5	Nil	6.52	0.11	9.00	2.25	0.40	0.44	13.90	L
2	Nawarwada Paddy field	29.0	38.4	32.6	30.0	47.3	2.4	1.3	49.7	3.8	Nil	6.75	0.053	9.50	2.50	0.42	0.38	14.67	CL
3	Dewalwada Paddy field	43.4	56.6	22.4	29.0	50.9	2.6	1.3	53.4	3.7	Nil	6.52	0.042	8.75	1.75	0.15	0.33	12.80	L
4	Dewalwada Paddy field	31.6	64.4	26.2	[illegible]	[illegible]	2.7	1.3	58.4	4.4	Nil	5.95	0.024	9.25	2.25	0.25	0.32	14.12	L
5	Sawal lena	23.2	75.8	40.4	[illegible]	[illegible]	2.8	1.2	62.3	10.3	Nil	5.74	0.057	6.50	1.50	0.36	0.30	10.23	C
6	Gawethone Coconut field	69.0	31.0	10.8	21.5	41.5	2.4	1.5	32.6	5.3	Nil	6.12	0.030	6.50	1.25	0.25	0.22	9.45	SL
7	Durbim mine (near DMC) Paddy field	41.3	36.2	58.7	30.3	[illegible]	2.3	1.1	62.0	4.4	Nil	5.14	0.072	7.25	1.75	0.28	0.12	11.12	L
8	Durbim mine (near DMC) Paddy field	[illegible]	30.6	30.6	47.4	[illegible]	2.6	1.09	64.3	4.0	Nil	5.14	0.062	6.75	1.50	0.28	0.20	10.78	CL
9	[illegible] VM Salgaonkar at Surla Paddy field	[illegible]	14.2	[illegible]	[illegible]	41.4	2.5	1.6	60.4	6.9	Nil	5.60	0.023	4.75	1.00	[illegible]	0.18	7.62	SL

Source IBM (Mining Research Cell)

Annexure 3.7 Analyses of samples collected from Sonshi mine area

Parameter	Afforestation dump soil (near generator)	Afforestation dump soil (top bench)	Agricultural land (Pissurlem village)
pH	6 5	6 7	6 9
EC (mmhos/cm)	0 15	0 17	0 31
P (Kg/ha)	13	27	23
K (Kg/ha)	7200	7200	7200
Sulphates (%)	0 28	0 08	Traces
Sand (%)	28	34	32
Silt & Clay (%)	72	64	68
Iron as Fe (%)	58	57	54
Organic matter (%)	0 50	1 26	1 09
Texture	Loam sand	Loam Sand	Loam Sand

Source. IBM (Mining Research Cell)

Annexure 3. 8 Analysis of samples collected at Pissurlem mine site

Physical properties	Silted paddy field foot hill side	Garden mixed plantation foot hill side	Proposed waste dump site	Paddy field near Pissurlem village
Gravel (> 2 00 mm) %	02.7	18 0	10.0	02 5
Sand (0 02-2 0 mm) %	55 2	46 0	59 3	27 8
Silt (0 002-0 02 mm) %	24 0	28 5	20 3	33 5
Clay (< 0 002 mm) %	20.8	25 5	20 4	38 7
Texture	Sandy loam	Loam	Sandy loam	Clay loam
Moisture retention				
1/3 bar %	26 8	30 5	27 2	34 6
15 bar %	15 7	14 2	16 5	18 8
Permeability (mm/hr)	92	80	97	78
Bulk density (gc/CC)	1 62	1 54	1 68	1 40
Chemical properties	5 4	5 5	5 3	5 6
Electrical Conductivity (mmhos/cm)	1 2	0 9	0 8	0 9
Carbon exchange capacity (meq/100 g)	8 6	10 4	9 3	12 4
Exchangeable Ca + Mg (meq/100 g)	1 4	1 9	1 2	2 4
Exchangeable K (meq/100)	0 04	0 16	0 05	0 40
Organic carbon %	0 52	0 67	0 48	0 63
Ammonical nitrogen %	0 03	0 04	0 03	0 03
Potassium %	0 42	0 61	0 49	0 52
Phosphorus %	0 02	0 03	0 02	0 03

Source. IBM (Mining Research Cell)

Annexure 3.9. General standards for discharge of effluents

Sl No	Parameters	Standards				
		Inland water	Public sewers	Land for irrigation	Marine coastal areas	
1	Colour and odour	See Note 1	–	See Note 1	See Note 1	
2	Suspended solids, mg/l, Max	100	600	200	a	For process waste water-100
					b	For cooling water effluent-10 per cent above total suspended matter of influent cooling water
3	Particle size of suspended solids	shall pass 850 micron IS Sieve			c	Floatable solids, Max mm
					d	Settleable solids Max 850 microns
4	Dissolved solids (inorganic), mg/a, max	2100	2100	2100	–	
5	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	
6	Temperature °C, Max	Shall not exceed 40 in any section of the stream within 15 meters down stream from the effluent outlet	45 at the point of discharge	–	45 at the point of discharge	
7	Oil and grease mg/l, max	10	20	10	20	
8	Total residual chlorine mg/l, Max	1.0	–	–	1.0	
9	Ammonical nitrogen (as N), mg/l Max	50	50	–	50	
10	Total Kjeldahl nitrogen (as N), mg/l Max	100	–	–	100	
11	Free Ammonia (as NH_3) mg/l Max	5.0	–	–	5.0	
12	Biochemical oxygen demand (5 days at 20°C) Max	30	350	100	100	

Sl No	Parameters	Standards			
		Inland water	Public sewers	Land for irrigation	Marine coastal areas
13	Chemical Oxygen demand, mg/l, Max	250	–	–	250
14	Arsenic (as As), mg/l, Max	0 2	0 2	0 2	0 2
15	Mercury (As Hg), mg/l, Max	0 01	0 01	–	0 01
16	Lead (as Pb), mg/l, Max	0 1	1 0	–	1 0
17	Cadmium (as Cd), mg/l, Max	2 0	1 0	–	2.0
18	Hexavalent chromium (as Cr + 6) mg/l, Max	0 1	2 0	–	1 0
19	Total chromium (as Cr), mg/l, Max	2 0	2 0	–	2 0
20	Copper (as Cu), mg/l, Max	3 0	3 0	–	3 0
21	Zinc (as Zn), mg/l, Max	5 0	15	–	15
22	Selenium (as Se), mg/l, Max	0 05	0 05	–	0 05
23	Nickel (as Ni), mg/l, Max	3 0	3 0	–	5 0
24	Boron (as B), mg/l, Max	2 0	2 0	2 0	–
25	Percent sodium, Max	–	60	60	–
26	Residual sodium carbonate, mg/l, Max	–	–	5 0	–
27	Cynide (as CN), mg/Max	0 2	2 0	0 2	0 2
28	Chloride (as Cl), mg/l, Max	1000	1000	600	–
29	Fluoride (as F), mg/l, Max	2 0	15	–	15
30	Dissolved Phosphates (as P), mg/l, Max	5 0	–	–	–
31	Sulphate (as SO_4), mg/l, Max	1000	1000	1000	–
32	Sulphide (as S), mg/l, Max	2 0	–	–	5 0
33	Pesticides	Absent	Absent	Absent	Absent

Sl No	Parameters	Standards			
		Inland water	Public sewers	Land for irrigation	Marine coastal areas
34	Phenolic compounds (as C_6H_5OH) mg/l, Max	1.0	5 0	–	5 0
35	Radioactive materials (a) Alpha emitters MC/ml, Max (b) Beta emitter μc/ml Max	10^{7} 10^{6}	10^{7} 10^{6}	10^{8} 10^{7}	10^{7} 10^{6}

Note

1 All efforts should be made to remove colour and unpleasant odour as far as practicable

2 The standards mentioned in this notification shall apply to all the effluents discharged, such as industrial mining and mineral processing activities, municipal sewage, etc

CHAPTER 4

The future of mining in Goa from a resource and a societal viewpoint

In this chapter the future of iron ore mining activities in Goa in the 15 year period 1997-2012 is projected in order to arrive at an estimate of which villages will have intense mining activity, which ones will have it tapering down, which will have new mining, and which will see mining activity close down. The chapter has two objectives (i) to project the iron ore to be mined in each of the villages by companies and leases for the 15 year planning period and (ii) to analyze the responses of the villagers to future mining activity in their villages. The first objective looks at mining from a purely resource point of view and the second looks at it from a societal point of view. In addition, a brief review of the country's iron ore production and exports in the past five years and the projections for 2001-02 and 2006-07 as worked by the Working Group on Iron and Steel for the 9th plan are also covered.

All India production and export of iron ore

The production and export of iron ore in India for the period from 1990-91 to 1994-95 are given in Table 4.1.

Table 4.1. All India production and export of iron ore (Mt)

Year	Production	Exports	Percentage of production exported (%)
1990-91	55.5	31.6	57
1991-92	57.5	29.9	52
1992-93	55.8	27.8	50
1993-94	58.7	31.4	54
1994-95	60.7	31.3	52

Source: Indian Bureau of Mines

It is observed from the table that there has been a marginal increase in production to cater to the increased domestic demand. It is also reported that the increase in production has come from existing mines and no major new mine has been opened during the last five years. The exports have hovered around 30-31 Mt per annum.

All India iron ore production projection by Working Group

The Working Group on Iron and Steel for the 9th plan has made projections of iron ore production for the terminal years of 9th plan (2001-02) and 10th plan (2006-07). The projections show that Indian iron ore production would increase from 60 Mt in 1994-95 to 94 Mt in 2001-02 and 108 Mt in 2006-07 to meet the increasing domestic demand. Kudremuk will produce 2.80 Mt of concentrate and 4.0 Mt of pellets annually. In addition to the above the Working Group has also indicated that an additional capacity of 18 Mt of iron ore capacity may come up by 2001-02 to cater to the requirements of the proposed new steel plants of TISCO, L&T & MESCO in Orissa, Jindal in Karnataka and additional requirement of SAIL (Table 4.2).

Table 4.2. Projected production capacity of existing iron ore mines in India (Mt)

Company	2001-02			2006-07		
	Fines	Lumps	Total	Fines	Lumps	Total
NMDC	17.7	11.5	29.2	17.7	11.5	29.2
SAIL	16.0	8.0	24.0	22.3	10.9	23.2
TISCO	3.3	4.5	7.8	3.3	4.5	7.8
Bihar/Orissa	1.5	5.0	6.5	2.0	7.0	9.0
Bellary Hospet	1.5	6.0	7.5	1.5	6.0	7.5
Maharashtra	1.5	0.5	2.0	3.0	1.0	4.0
Goa	13.0	4.0	17.0	13.0	4.0	17.0
Total	54.5	39.5	94.0	62.8	44.9	107.7

Source Working group on Iron & Steel for the 9th Plan Draft report

Iron ore production projection for Goa

As per the Working Group's projections, there is no significant increase in Goan iron ore production. This would increase to 17 Mt by 2001-02 and remain at the same level beyond this period. In addition, 2.75 Mt of iron ore (from Bellary) would be required for pelletization plants in Goa.

Based on our discussions with industry and government officials in Goa, it is felt that the Goan iron ore production has reached a plateau and would remain at a level of 15-16 Mt. In Goa, the production planning by companies are determined by the long term contract entered into with buyers. To arrive at the company wise production for the planning period 1997-2012, the following methodology has been adopted based on certain assumptions. These are as follows

- The total iron ore production from Goa will remain between 14-16 Mt/annum.
- The average production of companies over the last three years (1993-94/1995-96) has been taken as the annual future production from these companies. The average company total is taken as a constant for each year for the entire planning period.

- The share of leases in the villages in a company's total production were taken to be averages for the three year period using Department of Industry and Mines data
- GMOEA data on mine-wise ore production has been used because it was more comprehensive than the data from the Department of Industry and Mines.
- The in situ and recoverable reserves of iron ore for each mine (village wise) was obtained from IBM. The R/P (reserve-production) ratio was used as an indicator of how long the recoverable reserves will last to support the flow of current output. Using the R/P ratio as a planning and projection tool, the analysis identifies those leases, where at current production, mining activity may come to an end during the plan period This output from the leases that are to close down are then apportioned proportionally to other working leases of the mining company in order to maintain their annual total output at the same level as assumed in (ii) above It is evident that in actual practice the closing down and the apportioning will be a much gradual process to allow for increases in production capacity at the mine that has to handle the deficit in production However, for lack of detailed information about the rate at which this tapering and the apportioning will occur, we have assumed that it will done at a single point. The R/P ratio of the working leases are then recalculated after allowing for this additional output that has been added to them to arrive at new R/P ratio for the lease

Closure of mines in some leases

Using the above methodology, it is projected that production in 19 leases will close down during the period 1997-2012. There are however many leases that were not worked in 1996 but have applied for renewal in 1997. Assuming that these are granted, this indicates that even if all current working mines in these villages are closing or approaching closure, the village will still have mining activity arising from the development of new leases mines However, there was no information available to project production from these leases The cluster wise and village-wise details of projected closure of mines are given in Table 4 3

Table 4.3. Estimated life of mines based on R/P ratio

Village	Leases/Mines of	Closing down (year)
Cluster I		
Mulgao	Dempo	2016
Adwalpale	D Mangalji	2011
Sirigao	Chowgule	2027
	Bandekar	2023
Maem	Bandekar	2078
Lamgao	Dempo	1999
Bicholim	Dempo	1997
Bordem	Dempo	2003
Carapur		
Vainguinim		
Cluster II		
Cudnem	VMS	2007
	Timblo	2002
	Sesa Goa	1997
Surla	Dempo	2010
	VMS	2006
Valgum	VMS	2013
	DB Bandodkar	2003
Pale	Chowgule	2021
	Bandekar	2043
	V M S	2015
Sonshi	Dempo	2013
	S G Querim	2010
Vagurem	Chowgule	2010
Onda	Chowgule	2016
Pissurlem	D Mangalji	2003
	Sesa Goa	2019
Cluster III		
Sigao	Fomento	2012
Sangod	SMI	1999
	Lithoferro	2018

Village	Leases/Mines of	Closing down (year)
Cormonem	Dempo	2005
Codli	Sesa Gooa	2018
Santona	Fomento	2005
	Chowgule	2003
Costi	Chowgule	2034
Cluster IV		
Patiem	R S Gharse	2004
Tudou	Chowgule	2022
	R S Gharse	2009

Production plan for the future

Projection of iron ore production, based on the assumptions listed above, are presented under three scenarios

Scenario I Without adjustment of lost output due to closure of mining in some leases

Scenario II with partial adjustment of lost output

Scenario III. with almost full adjustment of lost output.

Under Scenario I, it is estimated that there may be a drastic fall in total production by approximately 10 million tonnes in the next 15 years since a number of mines would either close down or decline in production. Mining companies have probably already initiated action to maintain the production at the present level in the future Since we could not obtain the production plan of the mining companies, we have worked out the production plan under the above three scenarios In Scenario II, partial adjustment of production has been done for a number of mines based on R/P ratio This scenario shows a large shortfall from South Goa mines Therefore, under Scenario III, the shortfall has been covered to a large extent from 3 mines in South Goa, namely, Costi, Tudou and Codli and therefore, some of these areas show a sharp increase in production, which may or may not be justified. Since these areas have large reserves, it is feasible to plan for larger increase in production with due consideration to environmental impact It is also reported that 93 leases have been applied for renewal in 1997 as against 19 leases where mining may close down during the next 15 year period

The cluster-wise/village-wise production plan for terminal years of 9th plan, 10th plan and 11th plan are given in Table 4.4 Thus in Scenario I, iron ore production will fall to about 5 27 million tonnes, in Scenario II it will fall to 11.69 million tonnes and in Scenario III it will be almost fully adjusted and marked to about 14.36 million tonnes.

Table 4.4. Future production plan in the study area (lakh tonnes)

Village	Without adjustment (Scenario I)				Partial adjustment (Scenario II)				Full adjustment (Scenario III)			
	1996	2002	2007	2012	1996	2002	2007	2012	1996	2002	2007	2012
Cluster I												
Mulgao	1.01	1.01	1.01	1.01	1.01	7.89	11.25	14.48	1.01	7.89	11.25	14.48
Adwalpale	1.03	1.03	1.03		1.03	1.03	1.03	-	1.03	1.03	1.03	-
Sirigao	5.35	5.35	5.35	5.35	5.35	5.35	6.27	6.74	5.35	5.35	6.27	6.74
Maem	0.54	0.54	0.54	0.54	0.54	0.54	1.46	1.92	0.54	0.54	1.46	1.92
Lamgao	7.16			-	7.16	-	-	-	7.16	-	-	-
Bicholim	6.60	-		-	6.60	-	-	-	6.60	-	-	-
Bordem	1.79	1.79	-	-	1.79	1.79	-	-	1.79	1.79	-	-
Sub-total	23.48	9.72	7.93	6.90	23.48	16.60	20.01	23.14	23.48	16.60	20.01	23.14
Cluster II												
Cudnem	10.54	6.70	4.19	-	10.54	6.70	4.19	-	10.54	6.70	4.19	-
Surla	14.41	14.41	14.41	-	14.41	14.41	14.41	-	14.41	14.41	14.41	-
Valgum	8.30	8.30	1.78	1.78	8.30	8.30	1.78	7.85	8.30	8.30	1.78	7.85
Pale	10.98	10.98	10.98	10.98	10.98	10.98	11.91	18.44	10.98	10.98	11.91	18.44
Sonshi	3.30	3.30	3.30	1.36	3.30	10.18	13.55	14.83	3.30	10.18	13.55	14.83
Vaguriem	2.77	2.77	2.77		2.77	2.77	2.77	-	2.77	2.77	2.77	-
Oonda	0.24	0.24	0.24	0.24	0.24	0.24	1.17	1.63	0.24	0.24	1.17	1.63
Pissurlem	14.58	14.58	5.02	5.02	14.58	16.50	6.94	6.94	14.58	16.50	6.94	6.94
Sub-Total	65.15	61.28	42.69	10.38	65.15	60.08	56.72	49.69	65.15	60.08	56.72	49.69

[illegible]

Village	Without adjustment (Scenario I)				Partial adjustment (Scenario II)				Full adjustment (Scenario III)			
	1996	2002	2007	2012	1996	2002	2007	2012	1996	2002	2007	2012
Cluster III												
Sigao	10 81	1 81	1 81	1 81	1 81	1 81	5 81	5 81	1 81	1 81	5.81	5 81
Sangod	9 06	-	-	-	9 06	-	-	-	9 06	-	-	-
Cormonem	4 94	4 94	-	-	4 94	4 94	-	-	4 94	4 94	-	-
Codli	29 61	29 61	29 61	29 61	29 61	31 53	31 53	31 53	29 61	31 53	31.53	35 0
Santona	9 55	9 55	-	-	9 55	9 55	-	-	9 55	9 55	-	-
Costi	0 98	0 98	0 98	0 98	0 98	0 98	1 91	2 37	0 98	0 98	7 00	15 0
Sub-total	55 95	46 89	32 40	32 40	55.95	48 81	39 25	39 71	55 95	48 81	44.34	55 81
Cluster IV												
Patiem	5 00	5 00	-	-	5 00	5 00	-	-	5 00	5 00	-	-
Tudou	3 78	3 78	3 78	3 00	3 78	3 78	4 70	4 38	3 78	3 78	9 00	15 0
Sub-total	8 78	8 78	3 78	3 00	8.78	8 78	4 70	4 38	8 78	8 78	9 00	15 0
Total	153 36	126 67	86 80	52 68	153 36	134 27	120 68	116 92	153 36	134 2 7	130 07	143.64

Source. GMOEA (production data)
I B M. (Recoverable and in situ reserves)
Year represents financial year e g 2012 represents April 2011 to March 2012

The peoples opinion on future of mining in Goa

The previous section describes the expansion of mine production in some areas and the possible closure of certain mines In this context, the opinions of people regarding mining activity in their village becomes significant The people have expressed differing opinions about mining in their area. Their views are largely dependent on their previous experiences with mining and the prevailing socio-economic circumstances of the village

Cluster I

Majority of the households surveyed in Cluster I are not in favour of mining activity in the area Above 40% of the households do not want new mining in the area nor do they want expansion of the existing mining activity (Table 4 5) However, the households of Bordem hold opposing views to those of the other villages in the cluster Half of Bordem households are in favour of new mining activity in their village while Lamgao and Mulgao have only 6% and 14% of the households favouring the activity Lamgao and Mulgao villages are instead in favour of either freezing of existing mining operations or the complete closure of the mines A number of reasons have been put forward by the people for their views on mining which explain the extremes of opinion by people in adjacent villages

In Bordem, the settlement areas are relatively far from the mining activity Thus, the village experiences little of the mine related problems like siltation, pollution, etc To the people of the village, mining is a means of providing employment to the local people and thus it is felt that by encouraging mining in the village, local people are likely to prosper through greater employment opportunities

Table 4.5. Peoples perception about mining activity - Cluster I (% household)

Names of villages	Status of mining for the period 1997-2012	Villagers' views						
		About new mining activity			About fate of existing mines			
		Yes	No	Dont know	Expand	Freeze Capacity	Close	Dont know
Cluster I		33	41	26	40	[illegible]	[illegible]	3
Bordem	Closing	50	26	24	63	31	[illegible]	[illegible]
Lamgao	Closing	6	56	40	6	47	29	8
Mulgao	Expansion New	14	58	28	10	50	26	14
Sirigao	Expansion	25	54	21	30	56	11	4

Mulgao represents a completely different scenario Agriculture is the predominant economic activity However, the settlement area is located directly below the mines and one of the reasons for opposing mining activity in the village is the siltation of agricultural fields The villagers have stated that because of mining, the paddy fields that are highly productive slowly get silted by the runoffs from the mine dumps located above the fields. In addition to

the problem of siltation, there is another more real fear that of mine related accidents. The fear is a consequence of the a previous accident where the collapse of the Dempo mine benches led to a flood of water which caused the death of 5 persons of the village. All households of Gaunkarwada, one of the wadas of Mulgao, expressed their vulnerability to accidents stating that another accident similar to the one experienced previously will wash away all the houses in the wada. The village also perceives the problem of shortage of fuelwood as a direct consequence of increased mining in the area.

Sirigao is the other village in the cluster that is likely to experience the expansion of mining activity in the future. However, the views of the people clearly indicate that the village does not want increased mining activity. The objection to mining emanates from the feeling that the mine companies do not provide benefits to the local people either through employment or facilities. Instead the locals suffer due to the problems of dust and water pollution as well as siltation of agricultural fields caused by mining operations. As per the Department of Agriculture approximately 40 ha of paddy fields are affected due to siltation. Many of the residents of Sirigao also complained about the fact that mining in the village has occupied most of the land leaving little available for undertaking other development activities in the village.

As per the projections, Mulgao and Sirigao will support mining for approximately 20 more years. The concerns of the villages should have a central role in any plan for expanding mining activity in these villages.

Cluster II

Unlike Cluster I, majority of the villages in Cluster II are in favour of increased mining activity in the area (Table 4.6) despite being adversely affected as seen in Chapter 3. Villages such as Surla, Pale, Velguem and Ponocem are presently experiencing extensive mining activity. Many of the villagers are either directly or indirectly involved with mining. There are a combination of reasons that motivates the need among the people for increased mining activity. Firstly, the mines provide employment opportunities for the people. There are no illusions among the villagers about their dependence on mining hence, people have clearly stated that they would support increased mining in the village as long as locals were assured employment with the mines. Secondly, this dependence on mining is largely due to the lack of other avenues for employment. Thirdly, according to the people large tracts of the village are either owned or leased to mine companies, therefore, there is insufficient availability of land to undertake other forms of development activities. Fourthly, some of the mine companies have provided the local community with certain amenities which has led to an improvement in the relationship between the community and the mine company. An example is the water pipeline provided to Ponocem by a mine company. Besides, some mine

companies have made their pit water available for irrigation of village fields Another goodwill gesture by the mine companies.

Table 4.6. Peoples perception about mining activities - Cluster II (% households)

Names of villages	Status of mining 1997 2012	Villagers' views						
		About new mining activity			About fate of existing mines			
		Yes	No	Don't know	Expand	Freeze capacity	Close	Don't know
Cluster II		33	34	33	45	24	11	16
Surla	Closing, New	29	28	43	34	23	11	33
Pale	Expansion, New	32	30	38	45	30	6	20
Velguem	Closing, New	50	40	10	98	2	0	0
Ponocem	N A	83	17	0	100	0	0	0
Pissurlem	Closing, Expansion, New	31	20	49	51	19	16	14
Onda	Expansion	48	24	28	53	30	13	4
Arvalem	N A	39	59	2	74	3	22	0
Sonshi	Expansion	-	29	71	8	0	31	61
Vaguriem	Expansion		80	20	0	100	0	0
Cudnem	Closing New		46	41	7	63	12	18

N A Information unavailable

Nevertheless there are villages in the cluster that are strongly opposed to mining, these are Sonshi, Vaguriem and Cudnem All three villages have distinct reasons for opposing mining Sonshi village is located in the very heart of the mining activity in the village The houses are surrounded by mine dumps, most agricultural fields and cashew plantations are destroyed and dust pollution caused by the continuous movement of trucks and the proximity of dumps has made the lives of those living in this village an ordeal Households of Vaguriem view mining as an activity that has provided no benefits for the people of the village and only contributed in terms of greater water and dust pollution and destruction of land The village does not want an increase in the mining activity and expressed the view that the existing mine should not be allowed to expand

Cudnem is essentially an agricultural village The villagers vehemently disapprove of mining in the village as it is perceived to affect the agricultural production of the village. The residents complained that mining has led to the siltation of agricultural fields as well as the siltation of the local nullah which was previously used for irrigation and agricultural purposes. The information of the agricultural department supports this view as 60 ha of paddy

fields are identified as being affected by mining operations. According to the villagers, only a few people have benefited through employment with the mines, therefore mining has contributed little towards the improvement of lives of the people of the village

The information about mining in Cluster II indicates that it will continue for many years into the future in these villages The problems as experienced by some of the villages due to mining must be suitably addressed to ensure socially acceptable mining in the future

Cluster III

Villages of Cluster III are also in favour of increased mining in the area. Villages such as Sangod, Sigao, Darbandora and Cormonem are in favour of mining because it has provided employment opportunities for the people (Table 4.7). Some of these villages have high unemployment among the people Besides, being far remote from other economic activities, the people are largely dependent on the existing mining activities to provide employment People want that any new mining in their area should provide employment to the local people and not outsiders

Table 4.7. Peoples perception about mining activity - Cluster III (% household)

Names of villages	Status of mining 1997-2012	Villagers' views						
		About new mining activity			About fate of existing mines			
		Yes	No	Don't know	Expand	Freeze capacity	Close	Don't know
Cluster III		36	28	36	47	40	3	[illegible]
Codli	Expansion	25	28	47	49	45	0	6
Cormonem	Closing	11	0	89	75	25	0	
Sangod	Closing, Expansion	59	41	0	58	24	18	[illegible]
Santona	Closing, New	33	44	22	37	42	11	[illegible]
Darbandora	Closing, New	43	29	29	49	[illegible]	0	1
Sigao	Closing, New	48	15	37	52	44	4	[illegible]

Codli village is a case of near even distribution of population of those in favour of increased mining activity and those against mining. Households in favour of mining are those who view mining as a means of providing employment opportunities for the people However, households against mining expressed the viewpoint that mining has only increased the problems in the village through environmental degradation Moreover, the people also

complained about the problem of non-availability of land. Many felt that the mine companies own most of the village land and therefore no other activity can be developed in the area.

Among the villages studied in Cluster III, the people of Santona strongly opposed mining activity in the village. The rationale given for the opinion held was that the present mining activity in the village has worsened the lives of the people of the village. The people cited water pollution, dust pollution and siltation of agricultural fields as some of the consequences of mining in the village. The villagers also stated that mining was responsible for increased incidence of diseases among the people of the village.

Cluster IV

In spite of the fact that mining in Cluster IV is still very limited, villagers in the cluster are not in favour of increased mining in the area (Table 4.8). Households expressed the opinion that new mining should not be encouraged and those presently working in the area should have their capacity frozen leading to the final closure of the mine.

Table 4.8. Peoples perception about mining activity - Cluster IV (% household)

Names of villages	Status of mining 1997-2012	Villagers' views						
		About new mining activity			About fate of existing mines			
		Yes	No	Don't know	Expand	Freeze capacity	Close	Don't know
Cluster IV		5	35	60	7	88	5	0
Bati	New	6	31	63	9	91	0	0
[illegible]	Closing Expansion	0	33	67	0	67	33	0
[illegible]	Closing	0	60	40	0	80	20	0

The insistence of the villagers to end the mining activity is in response to the problems that mining is causing for the people of the area. Agriculture is the main means of livelihood. Villagers feel that mining has caused problems of water and dust pollution, as well as affected some of the agricultural fields of the area while providing no benefits to the local community. Through conversation with some of the local residents of the village and evidence of poor practices followed by the mine companies in the cluster, it is not surprising that experiences of mine related problems in other areas has made the local populace wary towards the increasing mining activity in their areas. However, there is a high percentage of households who were unable to provide an opinion on mining. This is probably because mining is still largely confined to small pockets in a village and many are unsure about the benefits or the costs associated with it.

Cluster IV will probably witness increased mining activity in the future, as a sizeable number of new leases are being applied for, for mining in this cluster. However, mine companies will have to redress their past wrongs to ensure that they do not face hostility from the residents of the villages.

Opinions about possible threat to health

Many of the households that are against mining, have identified the increased incidence of ill-health and morbidity as one of the negative impacts of mining. Households in each of the clusters were asked about what they believed would be the possible causes for ill-health the future. It is evident from Table 4.9 below that majority of the households in all the four clusters perceived that dust pollution would be the main cause of ill-health in their villages in the future.

Table 4.9. Perceived causes for health problems in the future (% household)

	Cluster I	Cluster II	Cluster III	Cluster IV	For mining belt
Dust pollution	45	57	50	40	54
Water pollution	13	17	22	33	18
Natural causes	0	1	3	13	2
Don't know	40	25	23	4	25
Others	2	0	2	0	1

17% of the households also attributed water pollution as a possible cause for increased incidence of health disorders among the people. Cluster IV feel highly vulnerable to water borne diseases, probably because a large number of cluster households are dependent on local rivers to meet their water needs.

Opinion about who benefits from mining

The cluster-wise distribution of the peoples opinion about who are the beneficiaries from mining indicates that for the surveyed villages of the mining belt, only a tenth of the total households feel that locals benefit from mining. Approximately 46% of the households (Table 4.10) feel that Non-locals are the direct beneficiaries from the activity. Many of the villages that do support increased mining in the village have categorically stated that increased mining activity must be subject to the condition that local people will be employed by the mine companies.

Table 4.10. Peoples perception about beneficiaries of mining

	Cluster I	Cluster II	Cluster III	Cluster IV	For mining belt
Locals	4	10	19	-	10
Non-locals	40	53	36	34	46
Both	29	27	22	26	26
Don't know	27	10	23	40	18

Summary

Although the views of the people in many of the village indicates that they would not like increased mining activity in their areas, there is no denying the economic dependence of the locals on mining activity. The main reasons for opposing the mining activity are

- Environmental problems such as siltation of agricultural fields and pollution of local water bodies which are largely a result of unscientific mining practices followed by the mine companies
- The contract labour system presently followed by the mine companies which is seen by the local people as reducing employment opportunities for themselves
- Lack of any initiative taken by the mine companies to improve the quality of life of the people living near the mines

If mine companies made a serious attempt to address these three basic issues, the community living near the mines may be more receptive to mining activity. Another important point to note is that since a number of mines will be closing, the mine companies need to plan for their closure in order to both avoid potential future environmental and social problems and also to reduce costs for themselves

CHAPTER 5

Environmental impact assessment and management strategies for control

In the previous chapter, the future of iron ore mining in Goa from a resource and societal view point has been discussed Based on the analysis it is projected that iron ore production will be maintained at the existing level (i.e. between 14-15 Mt/a) in the 15 year period (1997-2012). However, mining will close down in some leases and the production will be compensated from other leases. Overall, there will be no increase in the number of leases which were sanctioned in 1987 This trend of production will result in increased impacts on air, water, and land resources. The most important impacts are identified as land occupation due to mining and related activities, deterioration of water quality due to run-off from dumps and waste water from tailing ponds and poor air quality in mining villages and certain high traffic density road corridors. This trend of continued pollution would require that adequate and effective control measures be undertaken to ensure that environmental quality standards are met In this chapter, an assessment has been made of the various impacts on air, water and land due to mining and associated activities in the future and of the management strategies to control/reduce these impacts

Impact on land environment due to mining operations

As seen in chapter 3, the total land under mining and associated activities in the study area is estimated at about 3350 ha The total ore production till 1996 is estimated at about 350 Mt Based on these estimates the land area required for mining 1 Mt of ore works out to more than 9 hectares In the future, it has been estimated that the total ore production from 1997 to 2012 would be about 212 Mt, which is approximately 14 Mt/annum It is estimated that about 1850 ha of land would be affected by mining operations in the next 15 years (1997-2012). The clusterwise, villagewise details are given in Table 5.1 The land requirement is basically for expansion of pit area, dumps for ore and waste material and tailing ponds for benefication plants

Table 5.1. Clusterwise, villagewise ore production and land requirement for mining 1997-2012

Village	Land occupied under mining in 1997 (ha)	Cumulative ore production from 1997-2012 (Mt)	Cumulative land requirement for mining for 15 years (ha)	Remarks
Cluster I				
Adwalpale	47	1.4	13	Closing down in 2010
Sirigao	103	8.8	8	
Mulgao	82	13.3	120	
Maem	180	1.6	14	
Lamgao	59	2.1	19	Closing down in 1999
Bicholim	29	1.9	17	Closing down in 2003
Sub total	**500**	**29.1**	**191**	
Cluster II				
Cudnem	231	6.5	58	Closing down in 2007
Surla	169	17.0	153	Closing down in 2010
Velguem	109	10.0	90	
Pale	252	20.0	180	
	73			
Pissurlem	214	16.9	152	
Sonshi	189	16.7	150	
Vaguriem	31	3.8	35	Closing down in 2010
Honda	12	1.1	10	
Sub total	**1277**	**92.0**	**828**	
Cluster III				
Darbandora *	168			
Sancordem	86			
Sigao	8[illegible]	5.2	47	
Sangod	30	2.7	24	Closing down in 1999
Cormonem	28	4.4	40	Closing down in 2005
Codli	230	48.1	433	

Village	Land occupied under mining in 1997 (ha)	Cumulative ore production from 1997-2012 (Mt)	Cumulative land requirement for mining for 15 years (ha)	Remarks
Santona	220	7 5	67	Closing down in 2005
Calem *	22			
Dudal *	29			
Costi	26	8 2	74	
Sub total	**944**	**76 1**	**685**	
Cluster IV				
Patiem	4	4 0	36	Closing down in 2004
Tudou	151	11 5	103	
Bati	184	-		
Sub total	**340**	**15.5**	**139**	
Total				
N Goa	1777	121 1	1019	
S Goa	1284	91 6	824	
Goa	3061	212 7	1843	

Land rehabilitation status and future plans

During the last decade, the companies have taken some measures to reclaim the waste dumps by establishing vegetation cover From a study of satellite imagery (1997) and aerial photographs (1988), it is observed that an area of approximately 300 ha of waste dumps have been partially or fully vegetated. There is a backlog of 833 ha of dump area to be rehabilitated. In addition, out of the additional land likely to be damaged in the future 315 ha would be rehabilitated Therefore, the total land to be rehabilitated is estimated at 1150 ha in the next 15 years The villagewise status of reclamation of waste dumps in 1997 and the projected plan for reclamation in the next 15 years are given in Table 5 2 The following assumptions have been made for arriving at the projections for waste dump area and land reclamation based on past requirements

- Waste dump (as in 1997) is 85% of the total dump area
- Waste dump area requirement for future is taken as 35% of the total land area requirement for mining.
- Reclamation plan is taken as the balance area to be reclaimed + 50% of the additional dump area requirement.

Table 5.2. Villagewise status of land reclaimed and reclamation plan (1997-2012)

Village	Waste dumps in 1997 (ha)	Dump area reclaimed	Balance to be reclaimed as in 1997	Add dump area required upto 2012	Reclamation upto 2012
Cluster I					
Adwalpale	14	6	8	5	11
Sirigao	18	10	8	3	10
Mulgao	16	10	6	42	27
Maem	90	25	65	5	68
Lamgao	14	10	4	7	8
Bicholim	11	9	2	6	5
Sub total	**163**	**70**	**93**	**68**	**129**
Cluster II					
Arvalem	3	1	2	-	2
Cudnem	73	15	58	20	68
Surla	75	10	65	54	92
Velguem	40	10	30	31	46
Pale	88	50	38	63	71
Maulingui	30	23	7	-	7
Pissurlem	71	5	66	53	93
Sonshi	89	16	73	52	99
Vagurem	5	-	5	12	11
Honda	3		3	3	5
Ponocem	26	18	8	-	8
Sub total	**503**	**148**	**355**	**288**	**502**
Cluster III					
[illegible]	68	10	58		58
Sancordem	1	12	[illegible]		5
Rivona	37	6	31	16	39
Sangod	10	2	8	8	12
Cormonem	9	3	6	14	13
Codli	108	35	73	151	149
Santona	77	10	67	23	79
Costi	8	2	6	26	17
Sub total	**334**	**80**	**254**	**238**	**372**

Village	Waste dumps in 1997 (ha)	Dump area reclaimed	Balance to be reclaimed as in 1997	Add dump area required upto 2012	Reclamation upto 2012
Cluster IV					
Patiem	-	-		-	-
Todou	62	-	62	36	80
Bali	69	-	69	-	69
Sub total	**131**		**131**	**36**	**149**
Total	**1131**	**298**	**833**	**630**	**1152**

Impact on forests

In chapter 3 the total forest area affected by mining during the period 1988-1997, has been estimated at about 2500 ha. Clusters III and IV have more areas under forests In future, it is projected that the production of iron ore in clusters III and IV would remain at the existing level and therefore, the impact on forest land would be significant. In cluster I, there is no forest land and in Cluster II, the impact would be negligible. In cluster III, it is assumed that 10% of the total area required for mining in the future would be under forest which is about 68 ha In cluster IV, it is assumed that 25% of the area required could be under forest which works out to about 35 ha. Therefore, it is estimated that about 100 ha of forest land would be released for mining. The department of forest under the state government is aware of the problems For any forest land released since the 1980s, compensatory afforestation in an area equivalent to the land released is carried out by the forest department The cost of alternate land and the cost of afforestation are paid to the government by the company requiring release of forest land.

Resettlement and rehabilitation of affected population

It has been brought out earlier that future mining activities in the study area would require an estimated 1850 ha of additional land. Acquisition of this land may involve some displacement of population which would require a well conceived resettlement and rehabilitation plan We could not obtain any information on the population displaced in the past due to mining and also the benefits or package offered to them In chapter 4, we have also projected closure of mines in some villages but large scale expansion in other villages to meet the fall in iron ore output One such village is Sonshi where the production is projected to increase from 1.3 lakhs in 1996 to about 15 lakh tonnes in 2012 The socio-economic survey conducted in this village has also indicated the possibility of shifting all settlement of Sonus wada falling under this village

Sonus wada is situated very close to the mining activity in the village. The main road passes through the area forming a divide between the mines and the settlements. As the houses are very close to the road, the ore laden trucks that use the road throw up a considerable amount of dust which causes great discomfort for the people. Beside, the proximity of the mining activity and the reject dumps only adds to the misery of the people living in the wada.

As the situation has been becoming progressively worse, local people had approached the mine companies working in the area asking for relocation of wada to another site. Some initial interactions between the concerned parties did take place but no real headway was achieved. People have continued to live under hostile conditions of excessive dust pollution.

The socio-economic survey conducted, revealed this dissatisfaction and many residents mentioned the wish to be moved to another place. Therefore, we undertook a more detailed house to house survey of the wada. There are in total 51 households in the wada but only 47 are permanent households and out of these 36 households are agreeable to move to another area. Three households categorically stated that were not interested in moving, largely because they are landowners of the area. The others were tenants who did not express an opinion on the matter. There could be other settlements in the study area which are already affected or would be affected in the future. We are unable to predict the impact of displacement of population since no estimates are available either with the mining companies or the government.

Any resettlement and rehabilitation plan should consider the following points before a suitable package is adopted.

i) A detailed study of the affected population should be conducted

ii) Extensive community interaction to arrive at a package acceptable to all

iii) Site selection for rehabilitation colony or area

iv) Amount of compensation in cash/kind for land crops, trees, house, etc

v) Amenities to be provided in the rehabilitation area/colony

The cost of resettlement and rehabilitation has to borne by the companies involved. State government department of revenue and land records has to be involved fully in the process. Since we could not obtain any details about likely displacement of population from mining areas, this measure has not been costed. However, being an important issue in any mining project, it needs careful consideration. As an example, the rehabilitation package being presently followed in the coal industry is given below. Even though it is followed in full, this package has not helped in solving all issues involved in R&R, rehabilitation package in the coal industry. This only underscores the importance of R&R plan.

- Monetary compensation for land
- House compensation

- Thirty percent of value of land as solatium in consideration of compulsory nature of land acquisition
- Interest at the rate of 12 per cent per annum on the entire compensation accruing from the date of 4(1) notification till date of award[1]
- Plot of land of 0.05 acre in the rehabilitation colony.
- Resettlement charges to a maximum of Rs 5000/- per family.
- Transporting of salvaged house material to the rehabilitation colony
- Families which are not beneficiaries of employment for one member of the family are paid an economic compensation for 20 years at the following rates
  - Families losing land up to one acre: at the rate of Rs 300/- per month, plus an ex-gratia amount of Rs 100/- per month per family.
  - Families losing above one acre: Rs 300/- per month per acre subject to a maximum of Rs 1000/- per month plus an ex-gratia amount of Rs 100/- per month per family.
- Vocational training to be provided for one third of the affected population to help them in upgrading their skills..

Impact on air quality

As indicated earlier, the production of iron ore in the future will be maintained at the existing level of 14-15 Mt/a. Mining will lead to all associated activities like ore transportation, dry screening, beneficiation, and loading operations, and all these operations will continue at the present levels. All these operations would impact the air quality in the study area. The existing levels of air quality and the AQI for each village has been estimated in Chapter 3. As per our projections, iron ore production will reduce or close down in some village but expand in other villages to maintain the level of production between 14-15 Mt/a. The air quality status in the future (2012) for each village, has been estimated based on the following assumptions

- SPM concentration of 300-450 $\mu g/m^3$ per million tonne of iron ore production is considered for estimation of future SPM concentration levels for the surrounding villages. Present available SPM concentration levels surrounding mining villages also justify the above assumption
- Level of mining activity in each village

Based on these assumptions, SPM concentration level for each village in 2012 has

[1]Section 11 (A) of Land Acquisition Act, 1894, states that if no award of compensation is made within that period of two years from the date of publication of the declaration of acquisition, the entire proceedings for the acquisition of the land shall lapse.

been estimated. The air quality index for each village for 2012 has also been derived based on SPM levels and assumed SO2 and NOx levels The details are given in Table 5.3 It can be seen from the table that 15 villages have SPM concentration levels between 200-500 $\mu g/m^3$ in 2012 as against 12 villages in 1997 Out of these villages, 8 fall under 'Bad' AQI (5) 5 under 'poor' AQI(4) & 2 under fair AQI (3). These are as follows

Bad AQI Mulgao, Velguem, Pale, Pissurlem, Sonshi, Codli, Costi, and Tudou

Poor AQI Sirigao, Maem, Honda, Sigao, Santona

Fair AQI Surla and Cormonem

The air quality deteriorates in Mulgao, Maem, Pale, Honda, Sigao, Costi, and Tudou due to increase in production The production in Surla, Cormonem, Santona and Sanvordem will close down and hence there is an improvement in AQI in these villages

This is under the business as usual scenario (BAU) where it is assumed that the existing control measures adopted by the companies would continue in the future in the same manner

Table 5.3. Villagewise SPM concentration levels and AQI in 2012 (under business as usual scenario)

	SPM ($\mu g/m^3$)	AQI	SPM index		AQI index	
	1996	1996	1996	2012	1996	2012
Cluster I						
Adwalpale	202	47	2	1	1	2
Sirigao	265	67	2	2	4	4
Mulgao	205	[illegible]	2	2	3	5
Maem	160	[illegible]	1	2	2	4
Lamgao	218	[illegible]	[illegible]	1	3	2
Bicholim	190	[illegible]	1	1	3	3
Cluster II						
[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	3
[illegible]	220	[illegible]	2	1	3	3
Surla	260	[illegible]	2	[illegible]	4	3
Velguem	[illegible]	[illegible]		[illegible]		[illegible]
Pale	331	[illegible]	2	2	4	5
Pissurlem	330	[illegible]	[illegible]	2	[illegible]	5
Sonshi	310	[illegible]	2	2	5	5
Vagurem	135	32	1	1	2	2
Honda	170	45	1	1	3	4

	SPM (μg/m³)	AQI	SPM index		AQI index	
	1996	1996	1996	2012	1996	2012
Ponocem	190	53	1	1	3	3
Cluster III						
Sigao	228	58	2	2	3	4
Sangod	205	49	2	2	3	2
Cormonem	236	62	2	2	4	3
Codli	315	80	2	2	5	5
Santona	306	82	2	1	5	4
Dudal	160	42	2	1		
Costi	245	62	2	2	4	5
Sanvordem	292	74	2	1	4	2
Cluster IV						
Todou	218	56	2	2	3	5

Note:	SPM concentration microgram per cu m			<200	200-500	>500	
	Index			1	2	3	
	AQI	0-19	20-39	40-59	60-79	80-99	>100
	Index	1	2	3	4	5	6
	Quality	Excellent	Good	Fair	Poor	Bad	Dangerous

Fugitive dust from existing roads for transportation of iron ore in South Goan Mines

There are two major public road corridors which are used for transportation of iron ore from mines in Clusters III & IV These are I) Darbandora-Sanvordem road (11 km) for transporting ore to loading points at Sanvordem and Capxem, and ii) Ugem-Curchorem - Xelvona road (15 km approx) taking the ore to Xelvona loading point. Darbandora-Sanvordem road handles approximately 6 Mt per annum of iron ore and the Ugem-Xelvona road handles 1.5 Mt per annum. The towns Sanguem, Curchorem and Sanvordem are densely populated areas and the population is exposed to high dust levels, largely due to ore transport, and loading/unloading activities. In addition, these roads also cater to other goods and passenger traffic. Apart from dust pollution, there is traffic congestion on the roads and accidents The traffic also gets paralyzed frequently due to the congestion on the Sanvordem-Curchorem bridge. The measures taken by some mining companies to suppress dust by spraying of water has only worsened the situation by making the roads slushy and slippery The maintenance of these roads is also generally poor. The major cause for dust generation is overloading and over speeding of trucks. The problem is most alarming in the 6 km. stretch of Guddemol-Capxem road handling 5.4 Mt of ore and the 8 km stretch of Sanguem-Curchorem road.

It is estimated that there is an annual ore spillage of 1385-2770 t/yr (refer Table 3.1 for handling of 5.4 Mt of ore in the Codli-Sanvordem stretch and a consequent fugitive dust generation of 139-277 t/yr (7.4-12.3 g/s), leading to an ambient dust concentration of 850-1500 $\mu g/m^3$ in the surrounding areas. In the Ugem–Xelvona stretch, the ore spillage is estimated as 655-1310 tonne for handling 1.5 Mt of ore, and dust generation of 66-131 t/yr (3.5-5.8 g/s) leading to a dust concentration of 400-500 $\mu g/m^3$. These are much higher levels than the standard prescribed by the Central Pollution Control Board for residential areas (200 $\mu g/m^3$)

Existing railyard at Curchorem for handling Bellary ore is also a source of dust generation. Because of frequent public resentment against dust pollution, the Government of Goa constituted a Committee in 1994 (Fernandes Committee) to assess the dust pollution in Curchorem due to mining activities and recommend suitable measures to ameliorate the environmental effects. After studying the problem, the committee has recommended various measures including alternate transport routes and shifting of loading points to control dust pollution in the area. Diversion of ore traffic through the proposed alternate roads would reduce the dust levels and in the Curchorem area, apart from improving the overall air quality in the villages. It would also lessen traffic congestion on the public roads.

Ore loading stations on river Zuari

At present there are six loading stations located on either side of the river Zuari in the Curchorem-Xelvona stretch. The ore from South Goa mines is transported to these loading points. The ore from Bellary area used to be transported by rail (meter gauge) and was unloaded at Curchorem station. The quantity handed was less than 1 Mt annum. After railway gauge conversion (currently under progress), it is projected that 8 Mt of Bellary ore would be transported by rail for local consumption and export.

Because of the dust and other problems in Curchorem area, a Committee appointed by the Government in 1979 had recommended, among other things shifting of the railway stockyard from Curchorem to Xelvona. However, this could not be implemented due to strong opposition from the local population. The Fernandes Committee in 1994 has recommended that the railway yard for stacking Bellary ore should be shifted to Dukorkond in Santona village. In addition, the Committee has also suggested that, to solve the problem of dust pollution in densely populated areas, the ore traffic should be diverted away from Sanguem, Curchorem and Sanvordem towns. The loading points should be shifted to new sites in Panchawadi village of Ponda Taluka. The existing loading points in Capxem may continue. But loading point at Sanvordem should be discontinued. It is reported that two companies have already acquired about 58 ha of land for constructing new loading stations and stockyard in Panchwadi villages. This land was originally under wet land agriculture but

in one of the proposed areas, the land has, over the last five years, been colonized by dense mangroves.

Impact on water resources

In the previous section it is seen that the mining activities are affecting severely the river water quality and agriculture land in the study area. The major causes of water pollution are discharge of mine pit water, effluent discharge from beneficiation plants and workshop and storm water run-off from mine dumps and surrounding areas. Erosion of waste dumps due to heavy rainfall leads to turbidity of natural drainage system because of the suspended solids carried by the run off. The mines are pumping out ground water from the pits which is also very turbid. The most affected rivers are Bicholim, Madei, and Khandepar. The prominent nallahs affected are Cudnem, Sonshi and Advoi.

In future, with the continuing of mining activities at more or less the existing levels of production, all these factors will continue to result in pollution of the water bodies. The companies have adopted a number of measures to control water pollution but these control measures are neither adequate nor very effective, and there is a need to adopt improved control measures to prevent/reduce water pollution problems in the mining areas.

As a general practice, storm-water run off in the active mining area is allowed to go out of the lease area after passing it through filter bunds and/ or intermediate settling ponds. In some mines, lime is added which acts as flocculent to accelerate the silt settling process. During fair season, the pumped out water from the working pits is discharged to the natural water course after passing through filter bunds and settling ponds. Where the benificiation plants are present near to the working pit, the pumped out water is utilized in the beneficiation plant. For tailings a series of settling ponds are constructed. The discharge water after settlement of silt is either recycled in the benificiation plant or discharged into the river.

In general, the mining companies have taken some measures to reduce the adverse environmental impact on water bodies but these are frequently ineffective especially in rainy season. Even where the water discharge is meeting source effluent standards, they are not meeting the needs of the affected population for agriculture and domestic use.

The results of a short study on ground water conducted in a small but representative catchment area (Cudne river) has been discussed in Chapter 3. From the study it was observed that the shallow aquifer water levels are affected due to mining and this phenomena is site specific and time specific. The linkage between mine pit water and aquifer water is also evident from the study. The impacts of future mining on the ground water regime in the area cannot be estimated without a detailed hydro geological study of the area. The impact on land, water, and air quality in the future (under the business as usual scenario) due to mining has been discussed and quantified to the extent possible. Under this scenario (BAU), it is

assumed that the companies continue to adopt control measures as practiced today From the analysis, it is clear that, more effective additional control measures are necessary to bring in a significant improvement in the environmental status in the area. We have identified a number of strategies and these are discussed in the following paragraphs.

Management Strategies (MS) for control

Iron ore mining will continue to play a significant role in the economy of the area and the state in the future. A time period of 15 years has been chosen for the future plan The population in the area will increase leading to increased transportation and construction activities For achieving the desired objective of good environmental quality in the area, four different management strategies are proposed and evaluated These strategies, it must be emphasized, are not exclusive and can be taken up concurrently. These are as follows

- MS-1: Planned improvements including additional control measures
- MS-2: Fugitive dust reduction on roads and alternate roads for ore transport
- MS-3 Measures to alleviate societal problems affecting mining villages
- MS-4 Planning for closure of mines

MS-1: Planned improvements including additional control measures

Management strategy-1 confirms the need for additional abatement measures such as more effective water management, developing green belts around mining areas and in road corridors, closed water circuit in beneficiation plants, etc. Environmental degradation would be much worse without these measures as more residuals are generated with continuing ore production and associated activities The major environmental changes resulting from a switch from a business-as-usual scenario to MS-1 are as follows

- In spite of an effective traditional control programme, SPM levels in the mines would remain at the existing levels
- SPM levels in the villages surrounding the mines would improve significantly resulting in less exposure levels to the population
- The SPM levels in selected road corridors would decline marginally but would still have a positive impact on the settlements/population in some stretches
- The TSS levels in rivers/streams/nallah would reduce due to the improved abatement measures Pit water would be used for agriculture and domestic purposes Recirculation of tailing pond water would result in less water demand for beneficiation plants and zero discharge of pollutants into the rivers/streams

Reclaimed land in existing waste dumps will increase and the net disturbed land decreases in the area This would result in significant reduction of storm water run off from dumps

Abatement Measures

The abatement measures under this strategy are discussed under three sections — air, water and land restoration.

Air

Under this strategy the control measures adopted by the mining companies are strengthened and additional measures would be undertaken to control dust generation and its dispersion. When all the measures are adopted, it is estimated that the air quality index (AQI) in each village would be 2 which represents good air quality, i e SPM concentration levels would be <200 μgm/m^3 (which is the prescribed standard for residential areas) A summary of control measures being planned to be adopted for each dust generation sources is given in Table 5 4

Table 5.4. Control measures at dust generation source

Dust generation source	Control measures
1 Haul road	• Compaction & gradation and drainage on both sides • Regular water spraying by sprinklers • Chemical treatment of permanent haul road • Proper maintenance
2 Public road	• Two-lane roads properly constructed as per highway norms • Regular maintenance • Green belt on both sides of the road of adequate width (10 m)
3 Truck movements	• Prevent spillage by changing design of chassis All trucks to have a free board of 9' on the chassis • Overloading to be controlled by installing weigh bridges in the mines • Loaded trucks to be covered with tarpaulin or any other suitable material while transporting dry ore • Enforcing speed limit • Introduce wheel wash system of trucks at the mine • Spraying loaded trucks with water • Spraying on public roads should be totally stopped • Regular checks by government and mine officials to enforce these measures
4 Waste dumps	• Terrace dumping and compaction • Establish vegetation as early as possible
5 Ore dumps	• Establish green belt of sufficient width • Enclosed crushing and screening activities
6 Dry screening plants	• Green belt around the plants
7 Loading points	• Green belt around
8 Drilling	Dust collection system wet drilling

Many of the control measures are already implemented in some of the mines The additional measures which have been listed above are green belts around all industrial areas, experimentation with chemical spraying in permanent haul roads, improved mine and public roads and vegetation of dumps in a scientific manner. The Villagewise estimated AQI in 2012 under BAU and MS-I and the control measures to be adopted are given in Table 5 5

Table 5.5. Village wise estimated AQI under BAU and MS-I and control measures

Villages	AQI index in 2012		Control measures
	BAU	MS-I	
Cluster I			
Adwalpale	2	2	Better dump management, green belts
Sirigao	4	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, public road maintenance, better loading point management, closed dry screening plant
Mulgao	5	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, public road maintenance
Maem	4	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, water sprinkling in beneficiation plants , public road maintenance, green belt
Lamgao	2	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, water sprinkling in beneficiation plants , public road maintenance, green belt
Bicholim	3	2	Better dump management, public road maintenance, green belt
Cluster II			
Navelim	3	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks water sprinkling in beneficiation plants public road maintenance, green belt
[illegible]	3	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks enclosed dry crushing & screening, public road maintenance, green belt
[illegible]	3	2	Better dump management, haul road maintenance & chemical treatment check overloading, water spraying on loaded trucks public road maintenance, green belt
[illegible]	[illegible]	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, closed crushing & screening, public road maintenance, green belt

Villages	AQI index in 2012		Control measures
	BAU	MS-I	
Pale	5	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, public road maintenance, green belt, closed dry screening plant
Pissurlem	5	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, public road maintenance, green belt
Sonshi	5	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, public road maintenance, green belt
Vaguriem	2	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, public road maintenance, green belt
Honda	4	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, public road maintenance, green belt
Ponocem	3	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, public road maintenance, green belt
Cluster III			
Sigao	4	2	Better dump management, public road maintenance, green belt
Sangod	2	2	Better dump management, public road maintenance, green belt
Cormonem	3	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, water sprinkling in beneficiation plants , public road maintenance, green belt, closed dry screening plant
Codli	5	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, public road maintenance, green belt
Santona	4	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, public road maintenance, green belt
Dudal	2	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, public road maintenance, green belt
Costi	5	2	Shifting loading points, alternative road traffic route, green belt, better road & loading management
Sanvordem	5	2	Better dump management, haul road maintenance & chemical treatment, check overloading, water spraying on loaded trucks, public road maintenance, green belt

Note:

SPM concentration:microgram per cu.m.		<200	200-500	>500	
Index.		1	2	3	

AQI	0-19	20-39	40-59	60-79	80-99	>100
Index	1	2	3	4	5	6
Quality	Excellent	Good	Fair	Poor	Bad	Dangerous

Water

The control measures adopted by the mining companies are strengthened and additional measures are undertaken to control the suspended solids in the discharges from the mine and storm water runoff. These are described below:

Mine pit water

The pit water is of good quality, except for high suspended solids. The treatment scheme thus needs to focus on the removal of suspended solids from the water. Depending on the location of the mine and the need of the surrounding villages, the pit water is either discharged into the water body or can be used for agriculture and for domestic purposes. At all places, pit water must be treated to meet the prescribed standards before being discharged into water bodies. When the water is used for agriculture or domestic use, it should undergo further treatments. The treatment plan has to be suitably designed to meet the desired use for water. The important factors to be considered in selecting the appropriate method for treatment, are as follows.

- Laterite is locally available at very low cost. Various pilot studies and field installations on the use of laterite as filters have shown very good results. Therefore, their use should be encouraged to the extent possible.
- The flow and the quality of pit water varies seasonally. Therefore, the treatment scheme should be flexible to absorb these fluctuations.
- The quantity of pit water being discharged is very high, of the order of 4 Mld and in some mines it is above 10 Mld.
- The pit water is also slightly acidic having a pH of 5.0 - 6.0 and therefore needs neutralization.

Case I: Mine pit water to meet the standards before discharge: The use of laterite walls alone as treatment measure is effective only in very few cases where the turbidity of pit water itself is less and the flow is small. In general, laterite rocks alone are unlikely to produce good results. Therefore, it is imperative to have joint settling and filtration method. The solid particles in pit water are very fine and require sufficient detention time to settle For the flow rate of 4 Mld, the area required for the sedimentation tank for complete settlement of the particles will be of the order of 200 sq meters. The provision of such a huge size settling tanks will not be feasible in many mining areas. The problem could be overcome by the use of coagulants which will reduce the settling time of the particles and hence the area requirements for settling tank.

Use of coagulants for setting suspended solids: Thames water international (Triggs,et.al., 1989) have conducted some experiments on the effectiveness of lime and polyelectrolyte for the treatment of mine pit and tailing water. Encouraging results were observed with the use of polymer Magnafloc LT 25 and M 1011. However, the polyelectrolytes for the treatment of pit water can not be recommended for the mines due to the following reasons :

- The polyelectrolytes as a coagulant aid are effective only at a very narrow dosage rate (in the range of ± 0.3 ppm). The higher dosage of polyelectrolytes than the desired one generally resuspend the settled solids and increases the turbidity. Less dosage of the polyelectrolytes obviously can not produce the desired results. Since there are large fluctuations in both quality and quantity of pit water, the dosage requirements will be required to be monitored in the laboratory very frequently and accordingly adjustments are needed in the field. Going by the present manpower arrangements of the mining companies such a system may not work for a long period in all the mines.
- The residual toxicity of the water treated by polyelectrolytes has not been tested. In the past, it has been observed that the use of polyelectrolytes may increase the toxicity in water.
- The polyelectrolytes are sensitive with respect to the fluctuations in the pH and therefore needs skilled supervision.
- The recommended polyelectrolytes are not the name of the chemicals but they are the synthetic polymer manufactured by a particular company. As such there are chances of monopoly in rate-fixing or supply constraints in future.

Therefore, it is recommended that lime should be used as coagulant for the treatment of pit water. The use of lime will have the following added advantages :

- Lime is available locally at a very cheap rate.
- The use of lime will correct the pH of the pit water to near neutral.
- Heavy metal such as copper, zinc, lead and iron are coagulated in the pH range of 7 - 9 and therefore may get simultaneously removed.

The scheme for the treatment of mine pit water is shown in Figure 5.1. Lime is to be added to pit water in slurry form so that it gets well mixed with water. The dosage point of the lime would be in a mixing tank to be constructed at the upstream of the natural drain as shown in the figure. The receiving drain should be pitched with sandstone at the bottom and on the sides till 200 meters downstream of the discharge point. This would be followed by two laterite walls of minimum 1 m thickness separated by a distance of 100 m. The height and the width of the laterite walls should be sufficient enough to allow water to percolate only through laterites. If the percolation rate through the laterite wall is assumed as 40 $m^3/m^2/hr$, and the width of the natural drain as 4 m, then the minimum height required by the laterite wall for 4 mld flow rate should be at least 1.5 meters.

The lime dosage rate should be about 50 ppm. However, the optimum requirement of lime dosage should be worked out frequently by conducting the *Jar Test*. The frequency of conducting jar tests could be about a month, and in rainy season the frequency should be increased as there will be large fluctuations in both quality and quantity of pit water. Such a practice will not only produce better results but will also reduce the consumption of chemicals. The lime solution should be prepared at 5 % solids concentration in a mild steel

(MS) tank of suitable capacity. For the pit water discharge rate of 4 Mld, the capacity of the tank should be around 5 cubic meters so that the fresh solution is required to be prepared twice a day only. The lime tank shall be provided with an agitator for mixing. The agitator should be of turbine type with a necessary reduction gear box with suitable torque rating, motor, coupling, shaft and impeller. The shaft shall be of stainless steel and impeller should be of MS material with epoxy coating and shall rotate at 100 rpm. Necessary MS mechanical support across the tank shall be from ISMC. All the fasteners shall be of GI. The agitator shall be complete with :

- suitable capacity TEFC motor with class B insulation and IP55 weather protection suitable for 3 phase, 220 V, 50 Hz power supply
- automatic grease lubrication arrangement in a standard version to provide continuous lubrication to the bearing.

The mixing tank should be designed for a holding capacity of 3 minutes. The pumped out water should be allowed to fall freely in the tank so as to create turbulence necessary for mixing. The maximum depth of the tank should be 0.5 m and the weir loading at the outlet should be about 100 $m^3/m/d$. For 4 Mld flow rate the dimensions of the mixing tank should be 4.0 m x 4.0 m x 0.5 m. The outlet wall should be provided with 90° V-notches so as to have a total weir length of 40 m. It is necessary to provide adequate weir loading rate to avoid overflow from the tank. The receiving drain should be pitched with sandstone from the point of discharge of pit water to the laterite wall. This portion of the drain will act as the treatment zone for settlement of the particles. A pilot study is essential to know the percolation rate through laterite wall for appropriate design of treatment zone of the drain. The silts settled in the treatment zone should be cleaned frequently.

Case II: Pit water for agricultural use: The pit water which has to satisfy the specifications for use in agricultural fields should have an additional filtration unit at the down stream of the laterite walls and near to the discharge point for the agriculture fields. Except for solids, all the quality parameters of pit water are within the limits for irrigation purpose and therefore the filtration unit is required only as a polishing treatment so as to reduce the silt loads on the fields. The schematic diagram of the filters is shown in the Figure 5.2. The figure also shows the domensions required for a 3 mld treatment capacity plant. The filter bed would consist of three layers of laterite rocks of different sizes. The laterite filter bed is underlaid by a system of open jointed drains, which will lead the filtered water to the outlet drain. The effective size of the laterite rocks in the top, middle and bottom layer should be 5 mm, 15 mm and 35 - 50 mm respectively. The impurities present in water would be removed in the top layer and therefore the top layer consisting of fine laterite particles should be scraped out and replaced by the fresh layer at least once in a year to avoid chocking of the filters. The bed should be laid with even surface to facilitate even distribution of pit water over the filter bed.

Figure 5.1. Schematic diagram for pit water treatment under scheme 1.

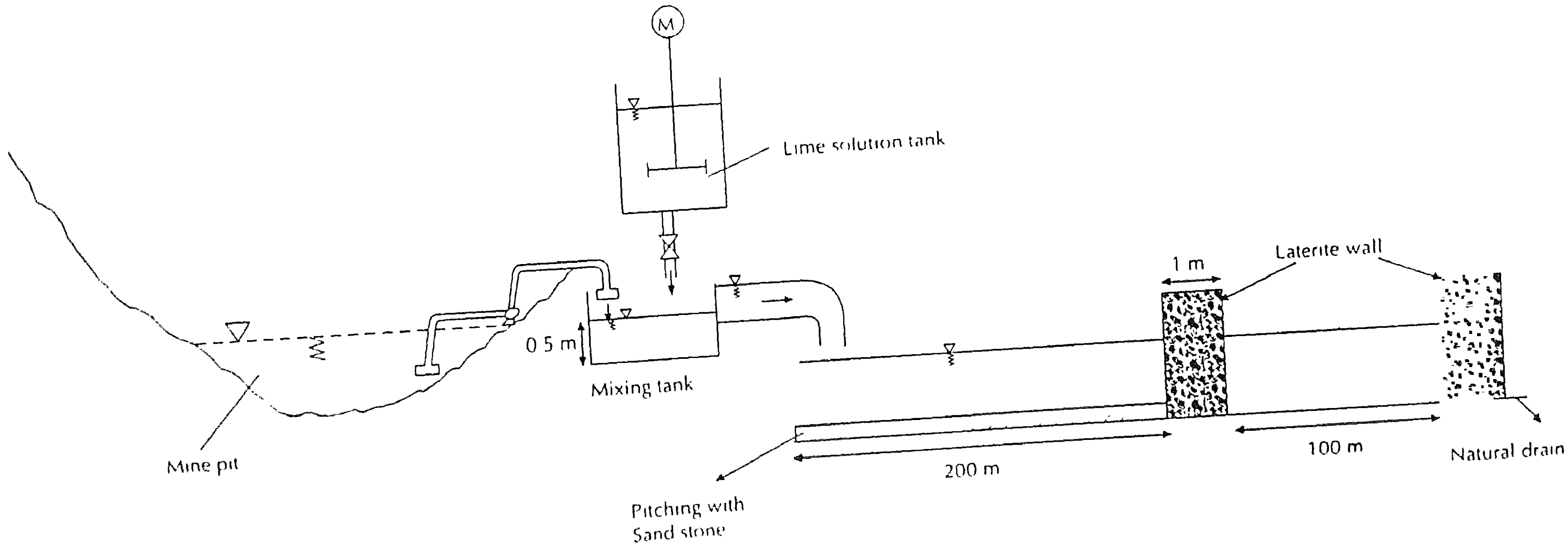
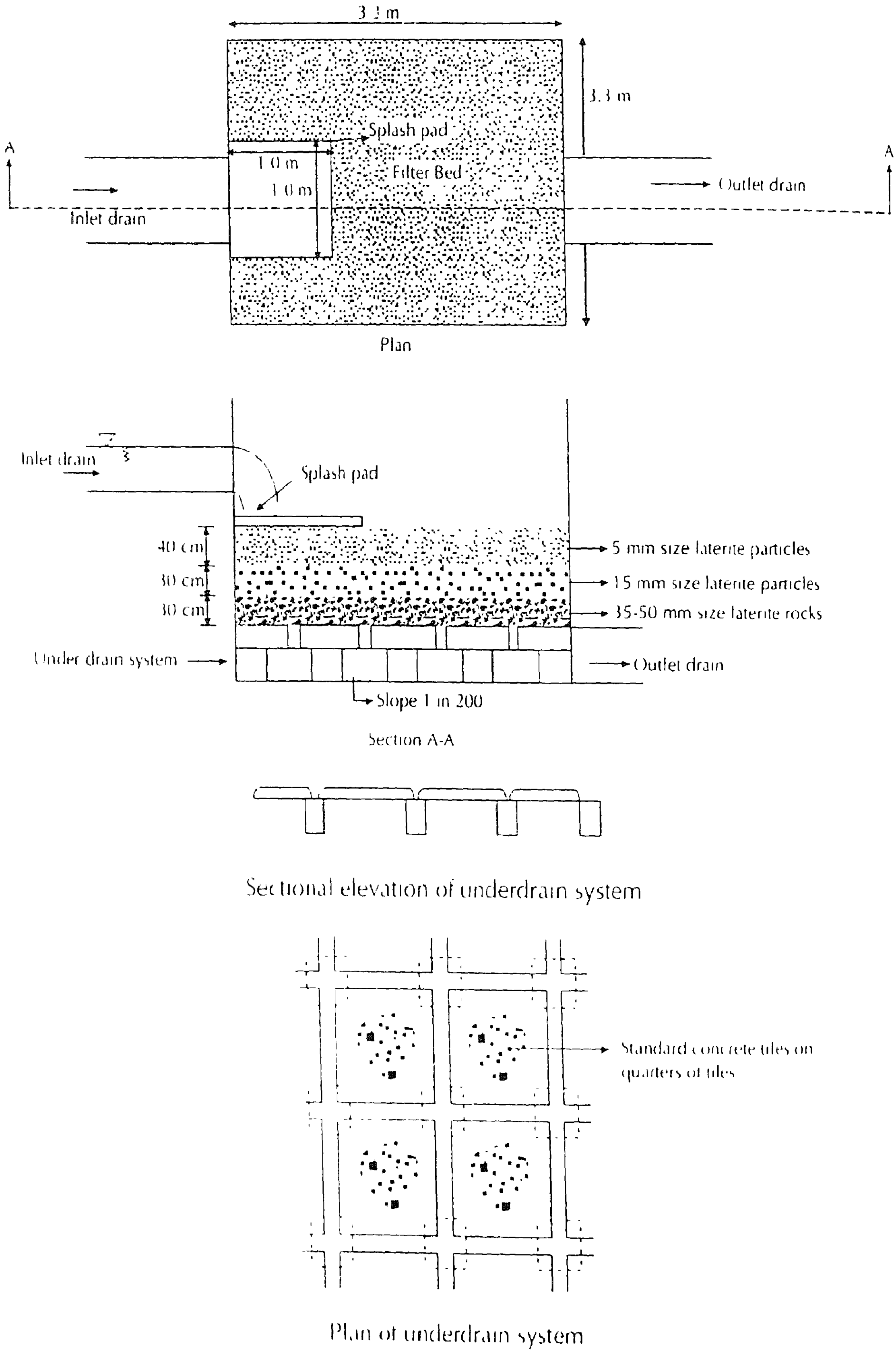


Figure 5.2. Filtration unit for 4 Mld treatment capacity - scheme II



It is necessary to conduct a pilot study to optimize the design parameters for the filtration unit. It is assumed that the filtration rate would be around 35 $m^3/m^2/hr$.

Case III. Supplying pit water after treatment for drinking purposes: Many villages in the mining area are facing acute shortage of water specially in summer months. Therefore, the mines which are working near to these villages can provide safe drinking water to the affected population. Many mines are supplying water to the villagers through tankers. However, the water supply through tankers is often found to be inadequate. Also the water quality of the tankers is poor and the villagers commonly complaint about colour and odour in water. Therefore, it is desirable to supply pit water after proper treatment.

The treatment scheme consists of collection of mine water in a central tank after initial treatment at the mines. All mines which are working within a radius of 5 kms from the affected villages could supply pit water to this tank. The quantity of water to be pumped to the central treatment tank should be sufficient to meet the demand of the affected population in the villages.

Water collected in the central tank will have a low concentration of suspended solids due to their pretreatment with lime and filtration. Further treatment of this water would consist of activated carbon adsorption. The activated carbon adsorption is suggested mainly to control taste and odour causing organics and removal of colour from the water. The system of Granulated activated carbon (GAC) for treatment of water would have following components :

- Carbon contactors for the water to be treated for the length of time required to obtain the necessary removal of pollutants.
- Reactivation or replacement of spent carbon.

Granular carbon prepared from coal should be used in the carbon contactors. The GAC contactors should be deep-bed, factory fabricated, steel pressure vessels for working in down flow mode of operation. Depending on the quantities of GAC invloved, the spent carbon may be removed from contactors and replaced with virgin carbon or reactivated either on-site or off-site. For large volumes, the on-site reactivation is more economical. For small quantities of carbon, replacement or off-site reactivation might probably be economical. A pilot study is recommended for detailed designing of GAC columns and to decide the frequency of the reactivation.

The objectives of the pilot column tests should be

- To determine treatability w.r.t. concerned pollutant parameters.
- To select best carbon for the specific purpose based on performance
- To determine the required bed contact time.

- To establish the required carbon dosage that together with laboratory tests of reactivation, will determine the capacity of the carbon reactivation furnace or the necessary carbon replacement costs.
- To determine the effects of influent water quality variation on plant operation & performance.

Mine Dumps

The management plan to contain the silt in runoffs from mine dumps is discussed elsewhere in the report. However, it is also recommended that in future the dumping of rejects should not be allowed within a distance of 500 m of a natural streams. Laterite walls of about 2 m thick and 3 m height at a distance of 100 m from the toe of the dumps should be constructed. The filtered water from the laterite wall should be collected in a drain and should pass through a settling tank before discharge into the natural drains. The garland drains should be of sufficient width and depth to carry the storm water to the settling tank. The settling tank should have at least at least 3 hrs holding capacity and the maximum depth of the tank could be 2 m. The surface overflow rate and weir loading should be in the range of 32 - 48 $m^3/m^2/d$ and 125 - 500 $m^3/m/d$ respectively.

Barges

The locomotive maintenance depots should be equipped with waste oil collection systems and provisions should be made to recycle the oil.

Benificiation Plants

In the process of beneficiation, a considerable quantity of tailings waste is generated. For the disposal of tailings waste a series of tailing ponds have been constructed and in many cases the settling process is aided by the use of coagulants. It has been observed that the water coming out of the tailing ponds has high concentration of dissolved solids for which the treatment procedures are very costly. It is therefore recommended that all the tailing water must be completely recycled within the beneficiation plant.

Workshop effluents

Effluent generated by servicing of the vehicles mainly contain pollutants such as SS, oil & grease, BOD and COD. Therefore, the provision of oil and grease trap alone cannot bring the effluent with in the acceptable discharge standards. The treatment scheme for this effluent is shown in Figure 5 3. It consists of baffled separator followed by coagulation by using alum and lime. The optimum spacing and inclination of the baffles needs to be studied in the laboratory for the effluents generated from service stations of mining area. Normally the baffle inclination of 45° and spacing of 10 cm produce good results. Similarly the optimum

dosage of alum and lime should be worked out in the laboratory. The following design specifications are recommended. The treated effluent can be used for gardening, etc.

Alum dosage	: 300 mg/l
Lime dosage	: 600 mg/l
Flash mixing period	: 1 minute
Flocculation period	: 15 minutes
Settling time	: 1 hr.

Land restoration

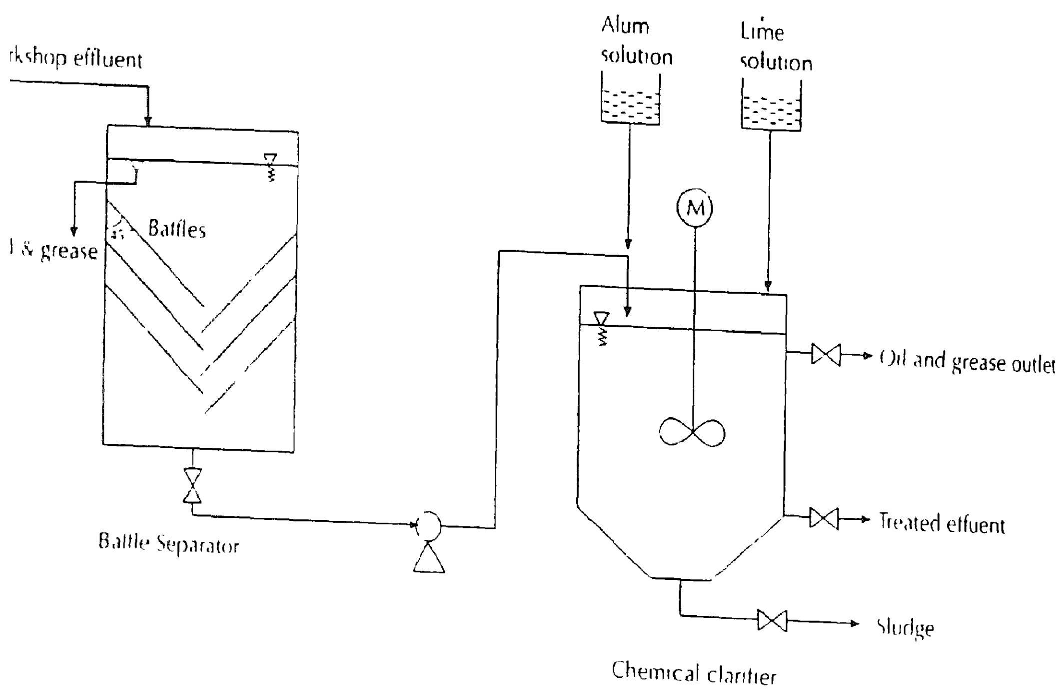
Restoration and conservation are in general inter-related and are complimentary. Failure to restore damaged resources may further damage the healthy resources. Dumps are often unstable and in a state of continuous deterioration. Therefore, efforts must be made to re-establish the whole ecosystems to the extent possible. The rehabilitation operations involved are soil and water conservation measures, raising of plantations of suitable species and strict protection from the biotic pressure. Till 1997, it has been estimated that out of 1131 ha of dump area, only 300 ha have been rehabilitated in some way, leaving a backlog of 830 ha. In the next 15 years, it is predicted that another 315 ha of land occupied by waste dumps would be available for reclamation. The restoration plan for existing and future dump upto 2012 has been worked out and the clusterwise details are summarised below. (Refer Table 5.2)

Cluster I	= 129 ha.
Cluster II	= 502 ha.
Cluster III	= 372 ha.
Cluster IV	= 149 ha.
Total	= 1152 ha.

Existing practice of dump restoration

Rehabilitation of dump area has become an integral part of mining activity in many mines in Goa Control of erosion is given importance in the rehabilitation programme. Most of the companies are adopting plantation on the natural slope of the dump (>30° slope) without reducing the dump slope to around 20-23 degree. A few companies are adopting terrace land forms. Top soil is not separately removed and stored.

Figure 5.3. Schematic diagram for workshop effluent



Plantation pits

Plantations in the mining belt are being done by seedlings commonly obtained from the forest department although some companies have their own nurseries. Before the on-set of monsoon, pits are dug of the size 0.3 cu.m. and seedlings are put into them with the onset of monsoon and properly rammed and dressed up. Mostly no fertiliser or manure is mixed with the material or no good soil or top soil pressured is used. This practice has met with mixed success. At places, depending upon these edaphic factors, reasonable success has been achieved, whereas in others the percentage success is rather low. Pits of the size 45 cm at the top, the same along the depth and 30 cm at the bottom may be better to provide better command volume of materials for the roots to tap at the initial stage of growth. Such pits dug much earlier than the onset of monsoon and filled up with imported good soil, if no top soil is preserved, and mixed with some amount of farm yard manure (about 1kg) and a little (15 gm) of mixed fertiliser (N, P.K in the ratio of 2:2:1) may serve much better purpose. Contrary to some opinion, fertiliser will almost certainly be necessary. While it is true that many species, especially the natives, are adapted to low nutrient levels, most derelict site materials will be far too deficient in nutrients for satisfactory growth; other sapplings planted may stagger for survival and/or growth. Where termite menace is likely, a little quantity of Aldrex or Aldrine or any other similar preparation may also be mixed up with the soil. Planting should be done with the onset of rains. Cashew is found to have been planted right at the first stage in some sites, and the tendency is picking up also. The larger pits with manures and fertilisers mixed, as suggested, may prove better for this purpose also.

Guidelines on dump management by IBM

IBM has issued certain guidelines on dump management and rehabilitation. The salient features are given below:

i) The design of the waste dump should accommodate progressive rehabilitation to ensure a minimum area of disturbance at any one time.

ii) The height, area, and shapes of the waste dump should be designed having regard to the area of land available, the general topography of the area, nature of material being dumped and climatic conditions.

iii) All completed surfaces of the waste dump should be stable and able to resist long term erosion.

iv) Top soil (20 cm) should be scraped out from the dump site in advance and preserved in low height dumps, duly covered with grass and vegetal cover to increase its life.

v) Previously stockpiled subsoil and topsoil should be spread on all completed surfaces where practicable and re-vegetated with suitable vegetation.

vi) The design and construction of the waste dumps should be such that the completed out slopes do not exceed 20 degree from the horizontal.

vii) Drainage should be constructed to handle heavy rainfall. Appropriate garland drains should be provided all around and specially to the ultimate boundary of the dump.

Technical reclamation of dumps

Long unbroken slopes, as existing in most of the waste dumps in the mines, allow surface run-off to accelerate and produce rill and gully erosion. Therefore, it is essential to reduce the slope of the dumps to about 20° (Figure 5.4) and even these should be of short length so that the overall height of individual bench is not more than 10 m and a berm of at least 4 m width should be provided. The berm should have a gentle slope inwards the dump. The rain water from the berm is drained through rock-lined vertical drains provided at suitable intervals. The number of vertical drains required is dependent on final slope angle. To increase the success of vegetation establishment, rehabilitation techniques should aim to increase rainfall infiltration. Infiltration can be encouraged by ripping and cultivating on contours and constructing contour banks. The most basic way is to leave the surface of the dump as rough as possible by deep ripping along the contours after the top soil has been spread. Ripping the surface will encourage infiltration, relieve soil compaction and increase the volume of soil readily accessible to plant roots. Ripping should always be along the contours.

Good dump management practice

The philosophy of progressive reclamation will be effective in waste dump management of Goa (see figure 5.5). In the disposal of the waste materials, the tipping may be done in several layers. Each succeeding and higher layer should have a basal area that is less than the layer below. Eventually, the whole waste heap will appear in the form of a step pyramid, each level connected to the one below, and eventually to the base level, by a spiral road way When tipping ceases on the first layer and commences on the second layer the sides of the first-tipped material should be prepared for planting, so that some form of restoration begins and is carried out while tipping is still in progress on the level above The process may be repeated giving three, four or even five layers of tipping and will dispense with the necessity to leave the area of land, that has been tipped upon, for a period of time before restoration commences Figure 5 6 shows the steps in the development of successful restoration scheme. As soon as an area is earmarked for dumping, a wall of laterite boulders (about 2 meter in height and 2 meters wide at the top and 3 meters at the base) may be erected all along the periphery of the proposed dump border about 3 meters away in the form of a toe wall. Adjoining the wall at its outer side a horizontal bed of laterite pebbles about 3 meter wide and 0.5 meter thick may be provided to act as filter bed. Another wall of similar specification may run parallel to the first at a distance of 15 to 20 meters. The intervening space should be

Figure 5.4. Dump profile design when space is limited

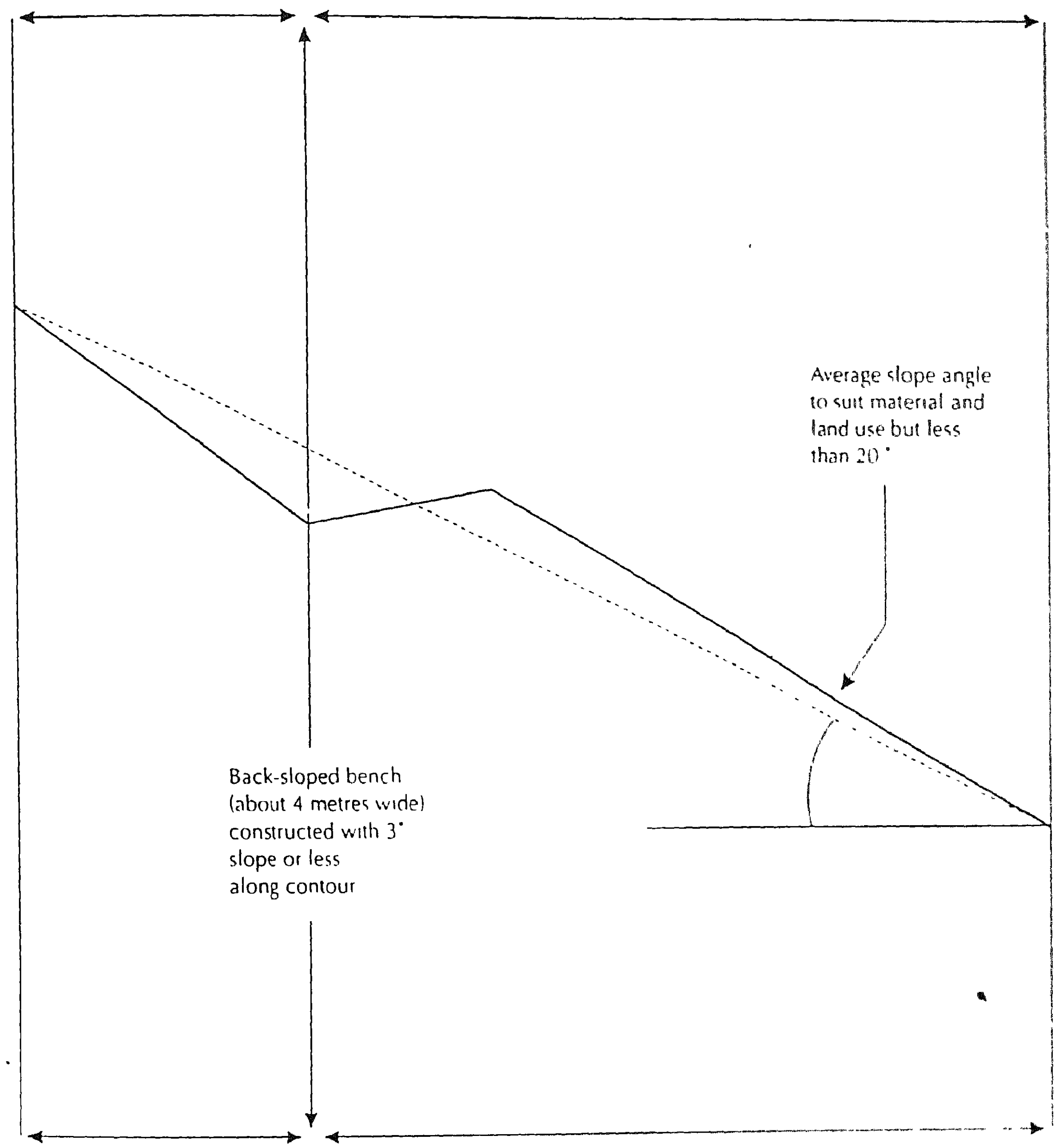


Figure 5.5. Restoration philosophy

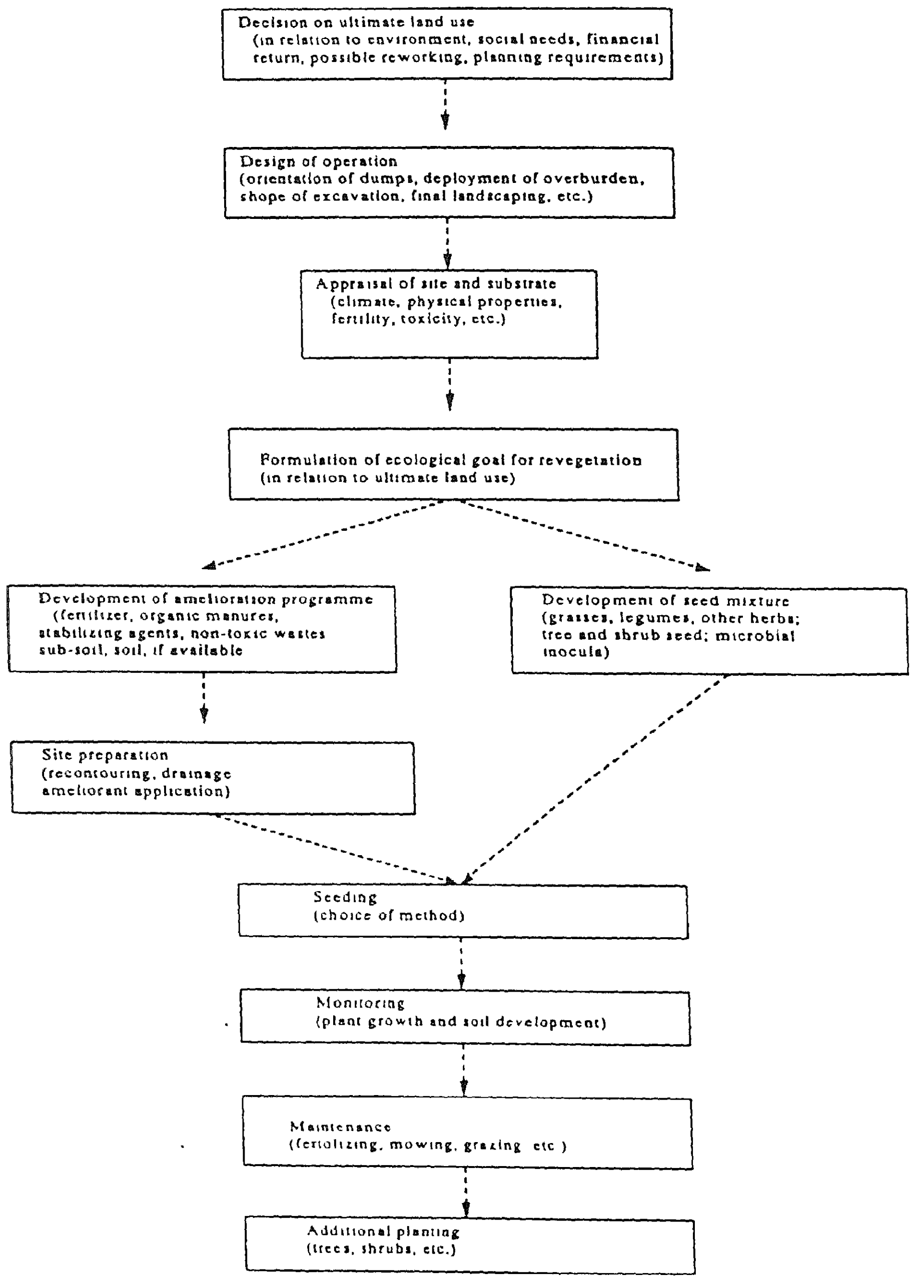
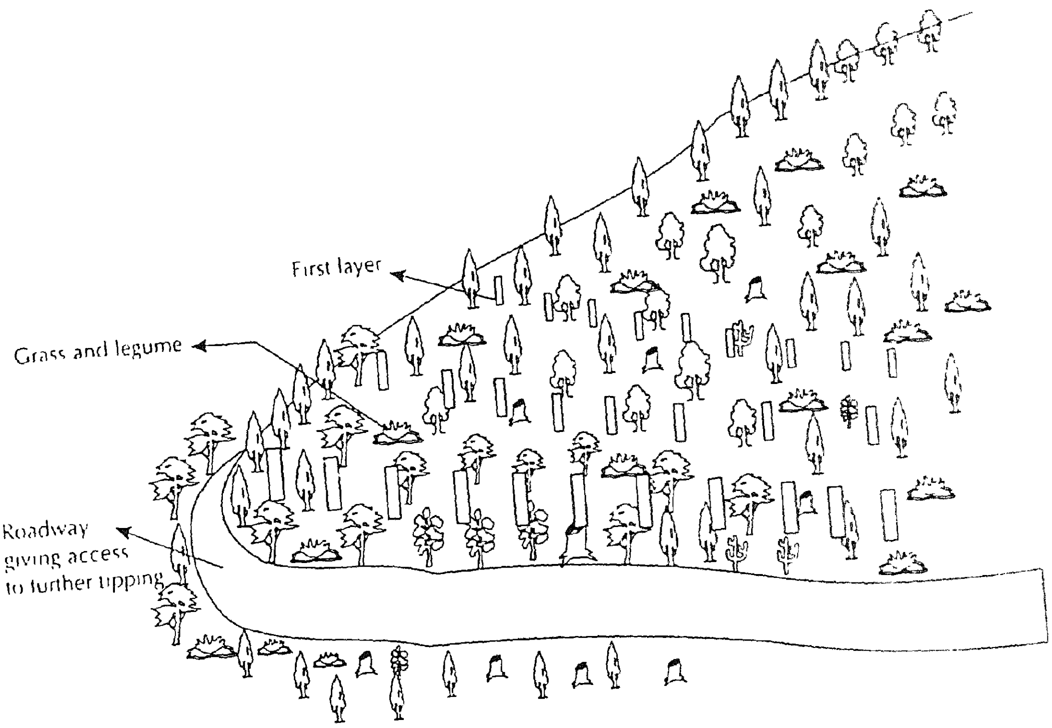


Figure 5.6. Progressive reclamation of dumps



densely planted up with suitable fast-growing hardy species to form a shelterbelt. On the outer side of the second wall another filter bed, like the first one, should be made. A garland drain (2 m x 2 m) should run about 2-3 meters away from this filter bed.

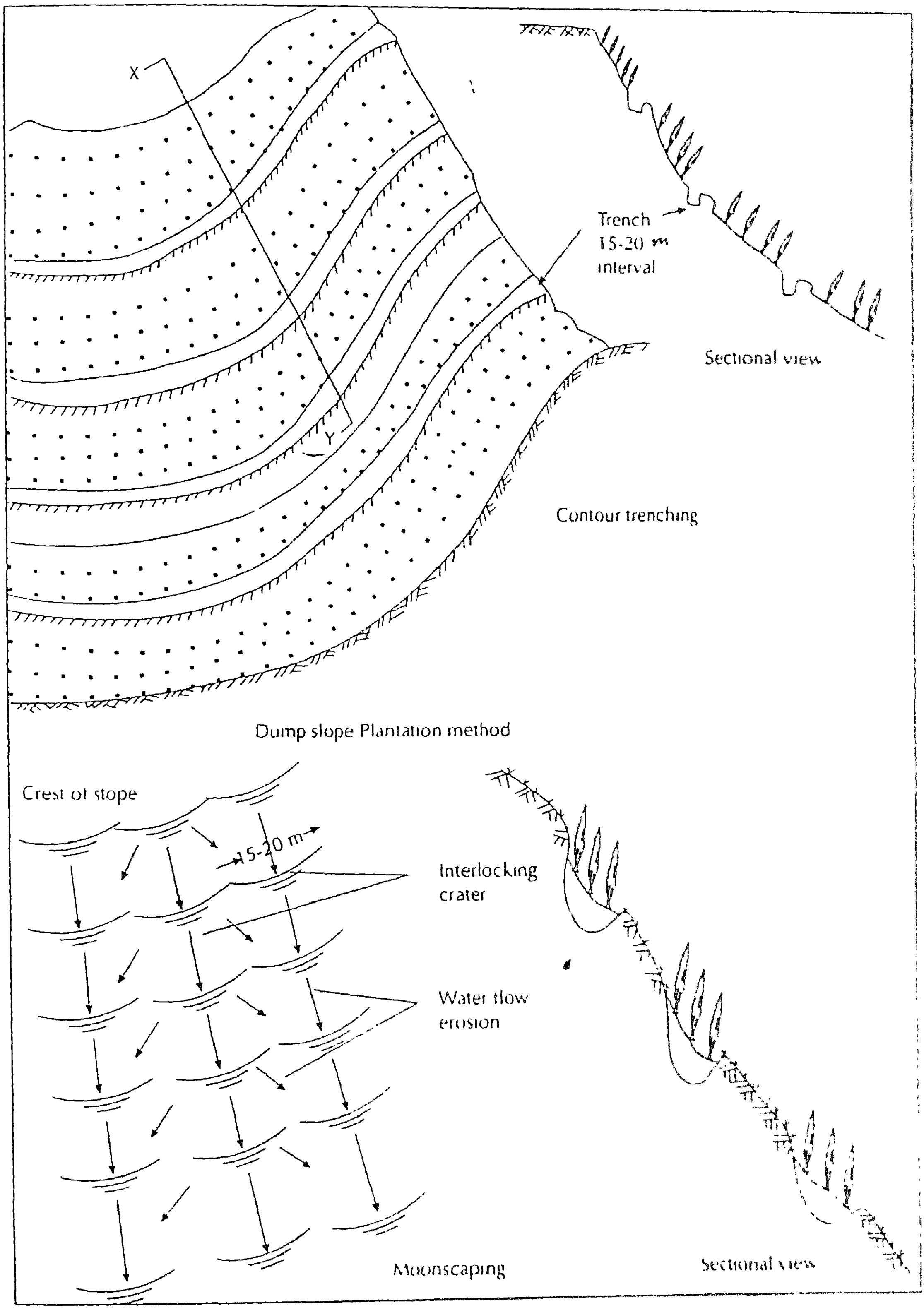
The aforesaid infrastructures should be ready before actual tipping of waste material starts. It is expected that the arrangement, with the plantations for shelterbelt attaining some growth by then, will be quite effective in checking run-off and erosion with progressive increase in height of the dumps as described earlier. Whatever small amount of suspended material in the form of silt and clay finally finds their way out of this system will get into the garland drain which can be suitably channelized into a settling pond. The recommended trees for the shelter bed plantation are as follows:

Table 5.6. Recommended trees for shelter bed

Plant Name	Characteristics	End use
Eucalyptus (Nilgiri)	Fast growing tall evergreen tree	Timber, construction poles, oil used for pharmaceuticals
Dendrocalrul (bamboo)	Needs some clay soil to establish. Its matty root system is an excellent soil binder.	Raw material for the paper and packaging industry, construction, basket and mat making, handicrafts. Leaves used as fodder.
Terma orientalis (gio, gol)	Fast growing, useful to improve soil.	Fuelwood
Acacia nilotica (babul)	Moderate sized fast growing tree	Timber, fuelwood, medicinal
Casurina equisetifolia (suru)	Fast growing tall straight tree	Fuelwood, timber, poles for construction

Moonscaping Figure 5.7 may also be taken up in some of the dumps depending on the slopes. Moonscaping may provide an alternate way to stabilize steeper slopes and improve conditions for revegetation It will improve water retention and availability also For moonscaping to be effective, it is essential that each runoff craters and mounds are interlocking to avoid channelling runoff On long slopes, a contour bank or bench may be required. Figure 5 7 shows reclamation of old dumps through revegetation

Figure 5.7. Reclamation of old dumps through revegetation



Top Soil Management

Topsoil is often the most important factor in successful rehabilitation, particularly where the objective is to restore a native ecosystem. However, no where in the mining belt of Goa, top soil was found to have been stripped separately, and preserved for future rehabilitation programme. In view of its crucial importance, in most situations, as far as possible the topsoil from all areas being cleared should be retained for subsequent rehabilitation. The topsoil contains the majority of the seeds and other plant propagules (Such as rhizomes, lignotubers, roots etc.), soil micro-organisms, organic matter and much of the more labile (more readily cycled) plant nutrients.

The term topsoil generally refers to the A1 horizon of the soil which is usually darker than the underlying soil because of the accumulation of organic matter. The complete A1 horizon should normally be removed. Avoid stripping deeper soil horizons which may have poor structure or high clay contents. When the A1 horizon is not obvious, the top 100-300 mm of soil should be recovered

The timing of topsoil stripping can be important for subsequent rehabilitation. Soils should not be stripped or replaced when they are too wet or too dry, as this can lead to compaction, loss of structure, and a loss of viability of seeds and mycorrhizal inoculum.

Topsoil should be replaced along the contour where possible. This will help in erosion control by reducing water flow down slope and increasing water storage. Wherever possible the topsoil should be immediately replaced on an area where the landform reconstruction is complete (known as 'direct return').

Direct return has several advantages compared with placing the topsoil in stockpiles and storing it for later rehabilitation. First, it avoids double handling. Second, the need to create stockpiles may mean that extra land must be cleared. Third, and most importantly, stockpiling reduces the quality of the soil resource Stockpiles become anaerobic, soil structure deteriorates, organic matter and nutrients may be lost, seeds deteriorate, other plant propagules die and populations of beneficial soil micro-organisms are reduced significantly.

If the topsoil must be stockpiled then it should be for as short a time as possible and

- the stockpiles should be low as possible with a large surface area - 2m high or less;
- the stockpiles should be revegetated to protect the soil from erosion, discourage weeds and maintain active populations of beneficial soil microbes (see section 3 3.4), and
- the stockpiles should be located where they will not be disturbed by future mining, as excessive handling will adversely affect soil structure

Tailings pond management

There is a sizeable area in the mining belt (200 ha approx.) occupied by tailing pond for dumping rejects from the beneficiation plants. The constituents of these tailings are not very different from site to site. They have high proportion of fine separates (silt and clay) admixed

with several chemical constituents, and pose difficulty to stabilize and vegetate. The majority of the tailings ponds have been sited more on the basis of site availability rather than on scientific/technical consideration. This aggravates the rehabilitation programme. The physical and chemical properties of the tailings material, need to be assessed to determine the extent to which vegetation of the tailings is practicable and what other options need to be considered. The most obvious inhospitable characteristics observed in the tailings are—
Lower pH values; lack of essential plant nutrients; textural and structural characteristics which limit aeration and infiltration.

The most economic and simple method of amelioration and vegetating these tailings is to have a self-sustaining vegetation cover for long-term stabilization and bring about change in their physical and/or chemical properties in order to support satisfactory plant growth. Some of the handy methods which can be employed to assist plant growth are—
Incorporation of organic matter and mulches, e.g., sewage sludge, organic mulches, flyash, etc., correction of pH; application of fertilizers after assessment of the nutrient status of the tailings pond material and use of topsoil to introduce essential micro-flora. After amelioration, the following species may be planted: *Acacia auriculiformis; Acacia nilotica, Casuarina Cumini, Eucalyptus sp ; and Ingudulis sp.*

Biological reclamation:

Sampling of the substrate: Sampling a site in its initial condition can give useful information about the nature of the material, which can be incorporated into the earth-moving specifications and landscape design and revegetation programme. Both the number of samples to be taken and the distribution of samples over the site are important, as well as, depth of sampling. Detailed physical, chemical and physico-chemical analyses of the dump material may be done in order to recommend proper ameliorative measures for dump stabilization, water retention, checking/monitoring erosion by wind and water and for revegetating the surface.

Of the physical analysis, those that give some idea of the water status of the waste material are most important. Water content, water availability and the moisture characteristics of the material will have direct effects on plant growth and indirect effects arising from the fact that chemical reactions take place in an aqueous medium. The parameters which are important are water content, infiltration, bulk density, particle density and mechanical analysis and water-stable aggregation.

When many of the essential nutrients are either in short supply or absent, chemical analyses of the waste material are indeed essential. pH, organic carbon, cation exchange capacity, exchangeable cations, total soluble salts, available N, P and K are some of the important estimations required generally. This will help in adopting proper ameliorative measure to suit particular vegetation programme.

Foliar Analysis: Plants growing on the site can be collected and analysed. This often gives excellent clues for the nutritional status of the sites and, again help in amelioration programme on easy manner. It is also useful for monitoring the progress of vegetation, particularly tree species, on reclaimed sites.

Plants, not necessarily the same species as those envisaged to be grown on the waste material dumps, are grown on the material in pots for a short period (2-6 weeks), harvested and analysed for a set of plant nutrients. This analysis has the virtue of revealing what can be taken up by the plants from the material naturally.

Field Trials: In order to monitor the performance of the species envisaged to be planted, small-scale field trials on suitable area may be carried out. Such a site should be truly representative of the dump material and also should receive all the subsequent ameliorative treatments based on the previous analyses. Performance should be monitored and, if necessary, further corrective measures taken. The observations made alongwith the set of treatments will eventually be translated to the dump as a whole for the purpose of successful revegetation. This allows a scope for judging the suitability of the species, and the package of treatments required, and ultimately help in avoiding failures in plantation programme on such a difficult site.

Revegetation with grass, legumes and shrubs: The prime consideration for revegetation of the derelict site of the initial stage should be to provide good vegetal cover to denuded sites in the shortest possible time. In what-so-ever rehabilitation programme has been done so far, with regard to the dump management, use of any cover crop has never received attention, with the result that although plantations with tree species mostly have been done, erosion of material from these dump slopes could not be checked especially at the initial stage when no organic debris on the surface could accumulate. Cover crops can be considered on such sites where a quick cover for erosion control is absolutely a prerequisite. However, when establishing plantations alongwith a cover crop, a compromise must be reached between the density of the cover crop needed to provide rapid erosion control, and the tendency of the cover crop to suppress or smother the plantation species

Right at the beginning the slopes need to be stabilized after technical measures are over In order to achieve that they may be planted up with grasses, legumes and shrubs as soil binder to control surface erosion and also to build up soil through incorporation of organic matter Grasses have wide adaptability, colonize fast and spread rapidly They bind substrate material through anchorage by proliferated root system thereby controlling erosion through surface run off, check dislodgement of particles by rain drop splashing and, in the process, add good amount organic matter helping convert the no-soil to soil. There are many different species to suit different environment, but it is their adaptability to a particular

condition that may matter. Legumes are crucial components in almost all grass mixtures because they contribute and maintain adequate nitrogen supplies and ensure the build up of an adequate capital of organic nitrogen in the newly forming soil. Usually, the most valuable legumes are those that are used in agriculture since they have high rate of nitrogen fixation. As such, a grass-legume combination may serve as an ideal cover crop at the initial stage of rehabilitation and will go a long way in protecting the sloping sites against erosion and over time these could also be used as fodder for cattle. A list of grasses and legume species are given below:

Agave americana
Arundo donax
Careya arborea
Crotalaria retusa/palida
Cynadon dactylon
Dichanthium annulatum
Digitaria decumbens
Dodonea viscosa
Imperata cylindrica
Ipomea carnea
Pennisetum pedicellatum
Tripsacum laxum
Vetiveria zizanioides

<u>*Revegetation with tree species*</u>: Due care is required for the proper choice of species of trees and shrubs. Species known to be well adapted to the local environment and based on the advice of the local forest department, may be chosen. In general, the most valuable species are those that are natural pioneers. Trees and shrubs can be established either by seeds, seedlings or transplants or by standards. Fertilizers and liming are important for trees and shrubs and also for grasses and legumes. If nutrient deficiency and pH are not corrected and maintained growth and development will be poor. It will be of advantage to introduce suitable tree species hand in land with grasses, legumes and shrubs.

A list of forestry and horticulture species recommended for dumps are given below. A list of some of the tree species with their characteristics and end uses are given in Annexure 5 1.

<u>Forestry species</u>
Acacia auriculiformis
Acacia catechu
Acacia mangium
Alstonia scholaris
Azadirachta indica
Bombax ceiba
Casuarina equisetifolia
Dalbergia sissoo
Dendrocalamus strictus
Eucalyptus tereticornis
Laucaena leucocephala
Michelia champaca
Peltoforum inerme/feruginium
Phyllanthus emblica
Polyalthia longifolia
Samanea saman
Sapindus mukorossi
Terminalia arjuna
Terminalia tomentosa
Xylia xylocarpa
Jatropha curcas
Jacaranda mimosaefolia
Cassia fistula
Cassia siamea
Saraca indica
Acacia nilotica
Pongamia glabra
Madhuca indica
Bauhinia accumuta/retusa
Nerium indicum
Thevetia nucifolia
Lagerstroemia flosregine
Trema orientalis

Macaranga paltata	Guava
Bauhinia racemosa	Coconut
Woodfordia furticosa	Betalnut
Butea monosperma	Pineapple
Horticultural species	Jack fruit
Cashew	*Ananas raticulata*
Mango	

Species Selection: In selecting species for planting in the area as a whole, the following broad-based points have to be considered.

- The species which form the group of pioneer species able to fix nitrogen -- nitrogen fixing trees.
- The species which are component of the natural forests which existed before degradation look place.
- The species which are fast-growing so as to provide vegetal cover in minimum period.
- The species which are capable to meet the requirements of the local people in respect of fuel, fodder, fibre, fruit, small timber etc.
- Tree species which have reasonable economic importance.
- Species of ornamental trees especially those which can provide greenery and aesthetics to mask the desolate look of the site.
- Species which have high tolerance for altered edaphic conditions and
- Species which can form mycorrhizal association easily for better moisture and nutrient uptake and, of course, better adaptability and performance.
- As far as possible, the indigenous species suitable for restoration of the ecology; although this aspect need not be over emphasized in preference to more suitable exotics capable of reclamation and higher productivity.

The choice of species for afforestation as also for horticultural plantations of such tracts is of paramount importance Firstly, the physiological conditions of growth are already adverse to the speedy recovery and rehabilitation of the area. Secondly, the biotic interfering factors make the situation still more uncongenial. Therefore, while selecting species for such inhospitable tracts not only these which are eminently suited for growth in such conditions are to be considered but take into account their origin, and provenance also. The saplings should be, as far as possible, from seeds from identical areas with respect to climate and soil.

Indigenous species found growing locally are most likely to ensure success. Introduction of exotics may be attempted after matching the ecological conditions of the trees and their habitats. *Acacia auriculiformis*, although not local or indigenous, but introduced years back, is result as well as time tested and has been indiscriminately used. This species

may be one of the first choices on all these derelict sites to start with. *Anacardium occidentale* (Cashew) has been found to do well on a fairly wide range of laterite/lateritic material. It may be planted right at the first stage wherever such materials occur as this will fetch good financial return while serving the purpose of vegetating the land.

When the first phase of revegetation of the derelict sites is over, which may take a few years (5 to 10 years) depending upon several factors like success of plantation, slope, etc. and when the land has attained reasonable stability and there is sufficient accumulation of organic debris returned to bring about biological activity, alternative propositions can be thought of. Sesa Goa has set an example in their Sanquelim area where the first-phase plantations are being replaced by more useful, commercially valuable species, of course, keeping the needs of the local people in view. This includes several horticultural species and some forest species apart from the common cashew crop. There is good scope for raising medicinal plants in the second stage. In fact, several plants of medicinal importance exist in the mining belt. Quite a few of them will help in building up the soil during their growth and development and also be a source of financial return. A list of some of the species of medicinal plants which are likely to do well is given below:

Medicinal plants

Acacia nilotica
Azadirachta acutangula
Baringtonia acutangula
Hydnocarpus laurifolia
Holarrhena antidysenterica
Helicteres isora
Carcinia indica
Syzygium cumini
Eclipta alba
Dioscorea bulbifera
Dillenia indica
Datura metel
Clerodendrum viscosum
Cassia tora
Calotropis procera
Calotropis gigantea
Buchanania lanzan

Green belt

Development of a shelter belt of vegetation on either side of the transport roads will go a long way in abating air pollution. Air pollutants in these roads comprise suspended particulate matters mostly. The green belt may be about 10m, consisting of three types of vegetation. The width of the greenbelt may be modified suitably depending upon the location, nature and load of pollution and other infrastructural settings.

The inner-most zone may comprise shrubs and middle storey vegetation meant for collection of dust raised from lower level due to vehicular movement. After a spacing of 3 meters taller trees with dense foliage will act as screen for the SPM. The third and forthmost row after another three meters may have still taller trees with again heavy foliage. Apart from SPM, this corridor or green-belt will miligate sound level also over and above adding

greenery on either side of the road. A mixture of *Eucalyptus teriticornis* may be given in the outer most row and some coarse varieties of tall grasses may be included in the first row. The species suggested are:

Acacia auriculiformis	*Piltoforum*
Acacia mangium	*Acacia nilotica*
Samania saman	*Nerium indicum*
Pthacolobium dulec	*Bongainvillea spectadilis*
Albizzia lebbeck	*Delonia regia*

MS-2: Fugitive dust reduction on roads and alternate roads for ore transport

The state is experiencing rapid all round growth in various sectors due to which movement of traffic in district and other roads would increase significantly in the future. The strengthening and widening of these roads have become necessary as the existing roads are not able to cater to the increased traffic. For rapid and smooth transportation of iron ore, it is necessary to provide good roads linking the mining areas. The government has plans to construct bypass roads catering to the mining traffic. MS-2 lays stress on improvement of roads and other measures for fugitive dust control and construction of alternate new roads for ore traffic. Abatement includes improvement in haul roads with water and chemical spraying the mines and improvement of mine and public roads. Major changes from a BAU strategy to MS-II are:

- haul roads improvement in mines including water/chemical spraying;
- mine roads/public roads to be strengthened and maintained in good condition;
- alternate roads for movement of ore in clusters III and IV, and
- alternate barge loading points for ore from cluster III and IV.

Abatement measures

Mine haul roads

Additional non-point source abatement measures would be implemented to reduce fugitive dust generation from roads, drastically reducing SPM levels. One set of measures would improve haul roads in mines. Fugitive dust for mining operations is the major source of air pollution in the area. Apart from regular measures like water sprinkling and use of dust extraction equipment, chemical sprays on haul roads can result in suppression of fugitive dust in the mining area. In addition, green belts around the mining and industrial areas would significantly prevent the dispersion of dust to surrounding villages.

Public roads

The other set of measures that would improve public and mine roads because the present roads are not in good condition. The strategy includes plans to strengthen, reinforce and widen most of the roads wherever feasible. It is estimated that about 50 kms. of mine roads and 120 kms. of public roads would be strengthened.

Alternate (new) roads

In addition, another major plan is to construct alternate roads for ore transport from South Goa mines to the existing and new loading points on the river Zuari. This involves about 20 kms. of new road and construction of two bridges on river Zuari and new loading points at two sites in the Panchwadi village for the loading of ore.

Chemical spraying on permanent haul roads in mines

The common preventive technique for the control of emission of fugitive dust from haul roads is by spraying water at frequent intervals. But water has relatively high surface tension which inhibits its ability to spread and thoroughly wet many materials. Also during the hot summer days, water gets evaporated fast and the road becomes dusty again. So the problem of fugitive dust emission remains the same. A suppressant or wetting agent, if added with water, decreases the surface tension, and wets the small particles, helping these to agglomerate into large pieces and thus prevents fugitive dust emanating from the haul road of surface mines. The use of chemical suppressants for the control of fugitive dust emission from unpaved haul roads has received widespread attention in the past several years. Hygroscopic salts, wetting agent and surface crusting agents are the commonly used chemical stabilizer to reduce the fugitive dust emission. Salts provide dust control by absorbing and retaining moisture in the surface material. Wetting agents enhance the mitigative effects of watering by lowering the surface tension of water, thereby, causing more rapid penetration into the surface material. Surface crusting agents, commonly petroleum products, are applied on haul roads to form hard crusts over the fine particulates. The control efficiency of these chemical stabilizers can be affected by many variables namely application parameters, vehicle characteristics, property of the surface to be treated and climate factors. The application parameters affecting the control performance of chemical dust suppressants are application intensity, application frequency, dilution ratio and application procedure. Few field trials of chemical dust suppressants were carried out in Indian iron ore mines, where overall 60% control efficiency was achieved by the application.

Alternate roads for ore transport from South Goan mines

The Committee on 'Dust pollution at Curchorem due to mining activities' has recommended that the ore traffic should avoid Sanguem, Curchorem, and Sanvordem towns. This would result in easing traffic congestion on the existing roads and also reduce air pollution. The Committee has suggested to construct the following by-passes and bridges in two stages. A copy of the map showing the alternate roads is given in Figure 5.8. The Committee has also recommended that an area of one hundred metres may be frozen on both the sides of the proposed diversion road so that the residential areas are receded back and will get less affected by the dust pollution. A green belt of 10 m width on both sides of the road would be established to prevent dust dispersion.

Stage I

1. Uguem-Costi-Guddemol-Gandhinagar-Capxem - 17.30 kms. Parallel road and bridge to be constructed.
2. Bridge at Xelvona should be constructed to transport ore on the other side of the river.
3. The railway yard for stacking Karnataka ore is to be shifted to Dukorkond by acquiring the land as shown in the plan and sprinklers should be erected at the railway yard to control dust pollution.

Stage II

1. Parallel bridge should be constructed at Sanvordem-Curchorem to reduce traffic congestion.
2. Construction of road along the river from Capxem to the proposed bridge at Xelvona. Construction by bye-pass from Capxem to Panchwadi - 2.5 kms., parallel to river Zuari.
3. Acquisition of required land along the road parallel to river to construct jetties.

The total length of new roads to be constructed is approximately 20 kms and in addition, two bridges are to be built on river Zuari It can be seen from the map that the trucks carrying ore from Codli area and Ugem area will converge at Guddemol and have to pass through a 2 km stretch upto Gandhi Nagar In addition, the ore from Bellary, if it is unloaded at Dukarkond, will also pass through this stretch which means that a total of about 12 Mt of ore will be transported through this stretch. This would have severe impacts on air quality. and traffic congestionon the Guddemol-Gandhinagar road corridor.

It may be advisable to consider a new road diversion from the existing Codli-Curchorem road at a suitable point in Santona village. This road can pass through Bandoli and Moisal villages and join the Mapa bypass. This road can be used exclusively for transporting ore from Codli and adjoining areas. The density of population in these villages is relatively low (kindly refer to Figures nos . .. & ...).

The diversion of ore from Codli area through the new diversion will result in reducing the traffic load on the Guddemol-Gandhi Nagar stretch with consequent benefits.

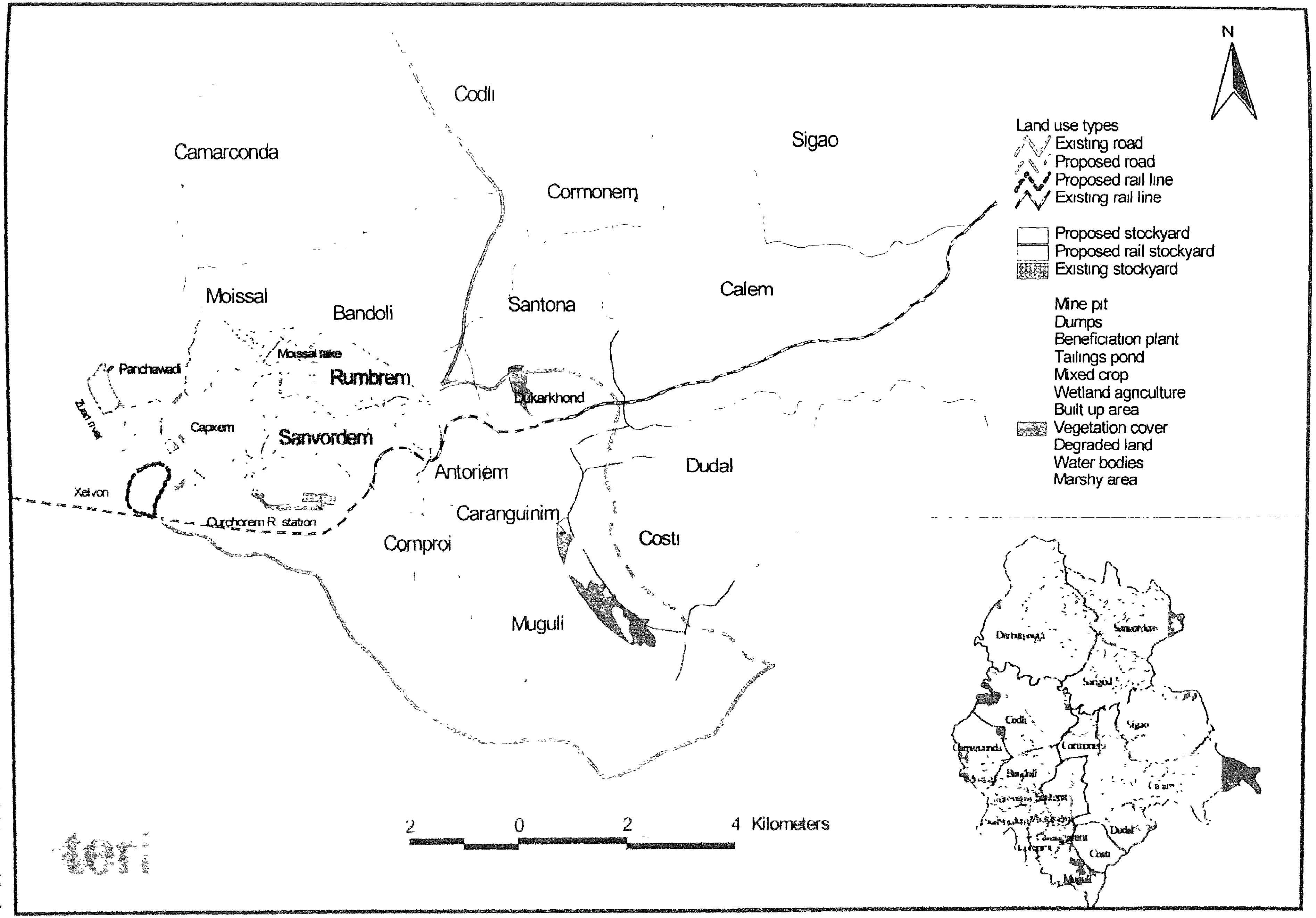


Figure 5.8 Alternative roads for ore transportation in South Goa

Environmental quality

Air

The predicted environmental outcome of management strategy II is good air quality in the three towns Churchorem, Sanvordem and Capxem. In addition, the dust concentration levels in the road corridors is reduced significantly. The construction of these roads, and shifting of loading stations would significantly reduce congestion of traffic and improve the air quality in the road corridors. The incidence of respiratory diseases in the population in the three towns would reduce. The population density along the proposed road corridors is low and green belts would prevent dispersion of fugitive dust.

Water

There are no significant differences in water quality when compared with MS-1.

Land

Additional land area would be acquired for the construction of alternate roads in South Goa assuming a right-of-way of 30 km for the roads.

Iron ore from Bellary-Hospet area

During the period Bellary-Hospet-Mormugao port main line was on meter gauge (MG), about four to five iron ore trains were run per day. Due to various technical reasons, the wagon tipping complex at the port was non-functional and the iron ore brought by these trains were unloaded at three stations on the route viz. Sanvordem, Kalem and Kulem, which are at a distance of about 41, 51 and 60 kms respectively from Murmugao harbour. The best daily average handling of metre gauge rakes at these stations was as follows:

Sanvordem: 2 rakes (about 76 M G wagons)

Kalem: 1.3 rakes (about 42 M G wagons)

Kulem: 1.25 rakes (about 41 M G wagons)

The iron ore brought to the above stations was transported by trucks to the industries for domestic use or to the barge berths near Sanvordem, if it was meant for export. At the level of unloading performance indicated above, the maximum quantity of iron ore that could be transported on the MG was only about 1 Mt/annum With the gauge conversion, the route capacity will increase manifold and taking advantage of the increased capacity, the Goan exporters and industrialists propose to transport about 8 Mt/annum on the broad gauge route It will be necessary to provide matching terminal capacity to facilitate this level of transport.

The requirement of rail transportation of iron ore from Bellary-Hospet area projected by the exporters and the domestic users is given in Table 5.7.

At Kalem station, M/s. Mandovi pellets have created infrastructure for unloading and transporting iron ore and hence propose to deal with the rakes consigned to them at this

station. Similarly, M/s. Sesa Goa will deal with the rakes meant for their pig iron plant at Kulem station. The balance quantity of 6 Mt of iron ore, which is meant for export, has to be unloaded at some terminal along the rail route. As mentioned earlier, the ore was unloaded at Curchorem station when the system was on metre gauge.

Table 5.7. Forecast of rail transportation of iron ore from Bellary-Hospet area (Mt)

Firm/year	1997-98	1988-99	1999-2000
(A) Exports			
MMTC	1.25	1.25	2.5
Sesa Goa	1.2	1.2	1.5
Fomento	0.5	0.5	2.0
Sub total	2.95	2.95	6.0
(B) Domestic use			
Mandovi pellets	1.5	1.5	1.5
Sesa Goa	0.3	0.3	0 3
Sub total	1.8	1.8	1 8
Total requirement	4.75	4.75	7.8

Source: Consultants Reports on transport of Bellary ore to Marmagao port..

The Committee set up in 1979 had suggested that the Bellary ore could be unloaded at a new terminal station at Xelvona. Based on this report, the South central railway had considered developing an unloading terminal at Xelvona on the Zuari river, about 2 kms from Sanvordem station. The area, where the terminal is to be built is very thinly populated, has adequate draft to accommodate barges of 2500 to 3000 tonnes and necessary area for stacking space. But because of public resentment on the location of terminal at Xelvona no work was undertaken. Subsequently, the Fernandes Committee (1994) had examined the problem of stackyard apart from all other causes of dust pollution. The alternatives considered for the Bellary ore terminal and stacking yard were:

I) to continue at the existing site in Curchorem; ii) shifting it to Xelvona; iii) taking the ore train directly to Murmagao port ,and iv) locating it at new site. Curchorem site is already a major source of pollution and has to be shifted. Xelvona site was rejected by the Committee since this is under wetland agriculture and is irrigated by canals and distributory pipes. Additionally, the local population has strongly opposed activities at the site. Murmugao port authorities have advised that they would not be in a position to receive the iron ore wagons at the port even after gauge conversion. Hence the iron ore rakes from Bellary Hospet sector have to continue to be unloaded at stations en route and transported by barges to the port as the port has no facilities to receive iron ore by any other mode of transport. After taking into

account all these factors, the Committee had suggested that the ore terminal station for Bellary iron ore should be located at Dukarkond and not at Xelvona. Recently, the Government of Goa had written to the South central railway authorities not to go ahead with their plans for designing and constructing a terminal station at Xelvona.

Environmental implications of locating the terminal at Dukarkond

Dukarkond site will require approximately 60 ha of land for stacking of iron ore. It is a low densely populated area. The village Santona, where the site is located, is presently in the highly affected category due to mining and associated activities. But it is estimated that the air quality level in the village would improve in the future provided the measures suggested under MS-1 are implemented. Moreover, it is projected that the mining activities would decline/close by 2010. However, an additional handling and transport of 6 Mt of Bellary ore would significantly affect the air quality of the area. The ore transportation, which would be almost equal to the total ore production from South Goa mines in the future, would have an impact on the road corridors. We agree with the Government of Goa's viewpoint that ideally the wagons from Bellary area should be taken to the port directly since apart from the environmental consideration, it would also help in easing the pressure on roads as well as the river.

MS-3: Measures to alleviate some of the societal problems affecting mining villages

In Chapter 2, it was clearly brought out that the people living in the mining villages experience shortages of key resources namely, water, land and firewood. Besides, these villages have limited access to employment opportunities as mining dominates as an economic activity. Furthermore, low literacy rates and lack of skills act as deterrents to greater economic well being for the people. This strategy covers measures to improve the quality of life of the population in the mining villages. The problems are:

- High illiteracy especially among the higher age groups
- Excessive dependence on mines.
- Inadequate availability of water
- Lack of sanitation and health facilities
- High dependence on firewood as a source of fuel.

Literacy campaign

The extent of literacy prevalent in an area is representative of the social development that has occurred in a village. According to the 1991 Census, the average literacy rates in rural areas for Goa state is as high as 75%. However, as the survey indicated, this is not the case in many of the villages in the mining belt. Villages like Pissurlem, Onda, Cormonem, Sangod and Darbandora have more than 30% of their population (above 6 years) who are illiterate.

The survey revealed that illiteracy is essentially prevalent in the higher age groups and therefore, the villages need a programme that will especially tackle the problem of adult illiteracy. Previously the government had undertaken an Adult Literacy Programme but this scheme has been abandoned. The reason mooted for this is the lack of funds. The programme should be restarted by the State Government.

Possible suggestions for implementing an Adult Literacy campaign

- It might be suitable to have 2 separate sessions for men and women. This is because often men and women have free time at different times of the day.
- The education should be done in the local language and emphasis should be on teaching basic reading and writing skills to the people.
- The programme should ensure that the entire community is provided an opportunity to avail the benefits from the programme.
- As far as possible educated unemployed youths of the village should be encouraged to be teachers for the programme.

Diversification and multi-skilling

Mining is an economic activity that is time bound, dependent on the availability of the resource that is to be mined. Presence of mining in an area leads to local communities becoming economicaly dependent on the activity, either directly or indirectly. When mining ceases, if adequate precautions are not taken, many of the local community will face a sharp decline in their standard of living.

In the mining belt of Goa, certain villages were found to have 40% or more of their workforce dependent on the mines. These are Velguem and Pissurlem, Sonshi, Todou and Ponocem. Some of these villages will be experiencing closure of the existing mines within the next 15 years. Thus, to reduce the impact of closure of mines on the people of the villages, there is need to start a process of broadening the economic base of these villages by providing alternative employment opportunities and creating new skills among the people.

Suggested non-mine activities

The socio-economic survey through its questions ascertained what non-mine activities the people would like to see initiated in these villages. The results are presented in Table 5.8. The households in Tudou village were unable to suggest alternative activities. It is difficult to ascertain the reasons for such a response. It appears that factories and industries are the preferred economic activities among the people of the villages. In fact for the mining belt as a whole too, these are the favoured suggestions. The probable reasons for these choice are:

- Factories and industry can provide employment opportunities to a significantly large number of people which is an important consideration given the high unemployment rates in the area.
- Often these activities require unskilled or semi-skilled persons which is suited to the local capabilities.

Table 5.8. Suggestions for economic activities (% households)

Suggested activities	Cluster II				For mining belt
	Velguem	Pissurelem	Sonshi	Ponocem	
Small Scale Industry	14.5	-	-	50	26.4
Factory	16 7	57 8	71 4	33.3	37.2
Large Industry	75	13.3	7 1	50	19.8
Agriculture training center	-	2.2	-	-	0.9
Others (pottery, banks tourist complex)	-	6.7	-	16.7	4.9
Don't know	-	17.8	-	-	3.8
Not interested	-	2.2	21 4	-	14.1

Source: Socio-Economic Survey, 1997

Note The columns do not add to 100 because of multiple answers

Features that need to be considered while planning for economic activities

- Vocational training should be imparted to the local population to ensure that they upgrade their skills for employment opportunities. This could be organized through multi-skill institutes or mini ITI's. In the mining belt, there are few such institutes and hence the population has remained largely unskilled.
- Local persons must be given first preference for employment. Employment of women must also be encouraged
- While planning for the activity care must be taken that the local environment is not adversely affected due to the activity.

Economic activities for women

Apart from the need of factories and industries in the villages there is a distinct requirement for income generating opportunities for women. Ability of a woman to earn an income is a positive step towards the emancipation of the woman through increased economic independence. Also of importance is the fact that it provides additional income for the family. In most instances income earned by a woman of the household is used to meet basic needs of food and clothing especially of the children. Thus, increased participation of women in the

workforce leads to dual benefits - economic as well as the social improvement of the family. Views of the type of economic activity that the women would like to see initiated were determined. Among the varied suggestions that were put forward by the women, tailoring is the most popular. The details are given in Table 5.9.

Table 5.9. New skills most wanted by women

Economic activities	Cluster I	Cluster II	Cluster III	Cluster IV	For Mining Belt
Tailoring	44.8	69	56.5	60 5	58.8
Basket weaving	11.7	15.9	10.1	2.3	12.6
Food processing (jam, jelly, papad)	2.1	10.8	13.6	-	9
Pottery	0.7	1.4	1.9	-	1.3
Poultry	0.7	11.6	13.5	14	9.9
Bee Keeping	0.6	0.5	-	-	0.4
Vegetable gardening	15.2	15.7	21.7	44.2	17.5
Any other	2.0	2.9	2.3	-	1.8
Don't know	24.8	5.5	6.3	-	8.2

Source Socio-Economic Survey, 1997
Note. The columns may not add to 100 because of multiple answers

Providing drinking water facilities

As indicated in Chapter 2, some villages experience shortage of drinking water during summer months. Under MS-1, we have suggested that the mine pit water, which is generally clean except for suspended solids, can be supplied to the affected villages. A group of mines within a range of 5 km radius from the affected villages can discharge the water, after initial treatment, to a common tank from where the water would be supplied to the villages after proper treatment. The details of the treatment scheme has been described under MS-1. In our opinion this could be a feasible option in which the companies bear the cost for discharge upto the common tank and the subsequent treatment, land area requirement are taken over by a government agency (PWD). Alternatively, the ground water has to be tapped in each village or a group of villages for providing local supply of water.

Providing sanitation facilities

Access to sanitation facilities is still extremely limited especially in rural areas. The mining villages were found to be no exception. The survey has revealed that none of the sampled households of Cormonem, Todou and Patiem have access to any sanitation facility. Such a situation can lead to serious health problems for the people of the village especially as there is considerable dependence on open water sources like local rivers, and low lying wells. Given

present situation there is an obvious need for toilets in the villages and therefore this orts recommends that some initiative must be taken towards constructing of public toilets hese villages. In the other surveyed villages less than 10% of the households were vided with sanitation facilities.

›vide adequate health facilites

per the Census information in Goa for every 750 persons there is a doctor. On the basis of average, it would appear that of the 23 villages which were surveyed, villages of Santona, ıgod and Ponocem, although having population higher than 750 persons, these villages e access to a doctor within 5km of the village.

Twenty villages have infrastructure in place for dispensing health services. However, re have been countless complaints by the residents of the villages that although Primary alth Service (PHS) exists, the doctor seldom visits the center. Pissurlem is an example of scenario. In this case the doctor from Valpoi is supposed to visit the PHS everyday but ording to the residents the doctor at best, comes once in a couple of months.

gestions

- The 3 villages identified without PHS should be attended to immediately and arrangements made to provide the necessary health service to the people of these villages.
- There is a need for the Department of Health to assess the existing health services in the villages and determine why certain villages despite having infrastructure, are not provided with the service due to them.
- Many of the mine companies have their own doctors who are available only to the mine employees. As there are villages without any medical services, the companies should be asked to make the services of their doctor available to the local community once a week. This need not be a permanent feature but an temporary arrangement till government services are made available to the people.

courage use of solar cookstoves

s evident from the socio-economic survey that firewood is the predominant fuel source for households in the mining belt. This high dependence on firewood implies that overtime natural vegetation is slowly depleted leading to a shortage of the resource. Households are n either forced to change to alternative fuel sources (i.e. gas and kerosene) or forced to el ever increasing distances to collect the wood required to meet their needs if modern ls are inaccessible or costly. All the three villages in Cluster IV are fully dependent on wood. The government should ensure supply of kerosene in the village. In addition, use of ır cookers can be promoted in the villages. This would require some amount of subsidy on cost and also training of women in the use of these cookers.

MS-4 Planning for closure of mines

Management Strategy-4 is a combination strategy incorporating elements from all 3 strategies. In effect if these elements are introduced into the mining belt, than what is obtained is integrated environmental management of the mining belt and the parallel concept of planning for closure from the outset of operations. For those mines, as is the case in this study, that are well into their project cycle, it implies adopting an integrated approach from the point of entry up until the closure of the mine. Such an approach will ensure that minerals development remains competitive while contributing to the sustainable development of the region. The main objectives of planning for closure from the outset and a whole life-cycle integrated environmental management of a mine include (Warburst et al., forthcoming, chapter 2).

- Reduced generation of waste and residuals
- Stabilization of residues to reduce potential of air quality related health issues and/or water contamination from the outset
- Disposal and containment of waste to achieve zero discharge over time
- Remediate and revegetate progressively
- Ensure that there are no health impacts detrimental to local community
- Ensure that local communities are not impoverished as a result of this activity or at the end of the mine life
- Spread environmental and social impact costs over life of mine

Benefits and cost of planning for closure

Planning for closure can generate benefits at two levels: First, at the level of the local community or region; and second, at the level of the mining company. Closure of mines, in the absence of any planned closure process may have the most serious consequences for local communities because of their greater dependence on a livelihood provided by the mining activity. A forward looking approach can involve developing viable economic alternatives, transforming mined land for productive purposes such as for growing cash crops, and timing new mining projects in the region to follow on consecutively. It can also provide the framework for the psychological adjustment to unemployment, however temporarily Planning for closure can enable the region's resources to be mined in a manner that does not result in a net impoverishment at the close of mining operations. and avoid damage to ecosystems that have a positive value to local communities and business activities.

The benefits of planning for closure to a mining company are that it:

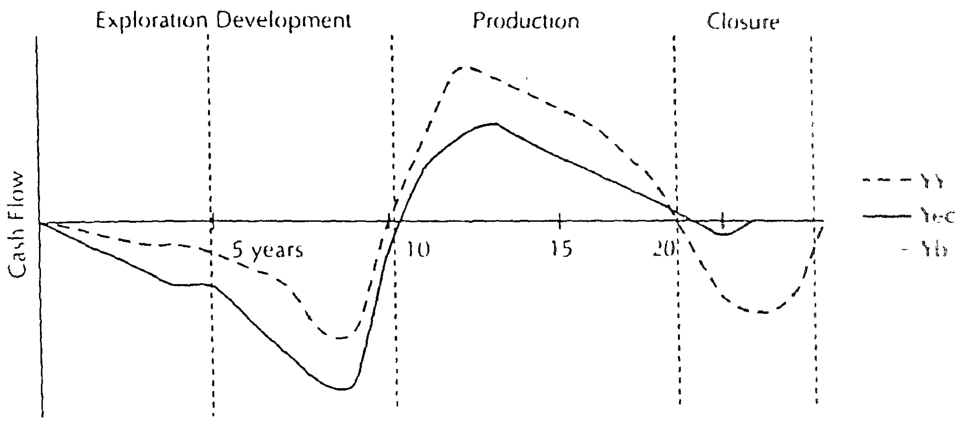
1. ensures that stocks of water, air, land (components of the natural environment necessary for production) are available for future operations.
2. provides a healthy environment for miners to work and live in and thereby maintains/increases the productivity of the workers.

3. reduces the extent and expense of final remediation.
4. reduces future risk of more strict regulation.
5. greener operations improve the company's profile and track record.
6. reduces tensions and conflicts within local communities.

The attractiveness of the concept of planning for closure as a whole life-cycle approach to managing the environmental impacts from mining from the development stage through operations to closure, is rooted in the time factor. The greater the time lapse between the occurrence of environmental damage and its remediation, the greater (in most cases) will be the resources (both human and financial) necessary for addressing the problem

The demand for financial resources at the time of closure will occur at a time when the firm is experiencing a reduction in cash flows. Integrating environmental management through planning for closure from the outset will enable the firm to provide for the costs of closure during the period of positive cash flows. This is illustrated in Figure 5.9 whereYY represents the cash flow curve uncorrected for environmental impacts that may continue or arise at the time of closure. If the firm operates in a regime in which there are no closure responsibilities, then the curve will follow the trajectory of YY. If the firm has closure esponsibilities, and there has been no planning for closure, the firm may need to incur costs at the time of closure which will burden the cash flows at a time of substantially reduced cash lows. The cash flow curve will then have the shape of YY. An integration of environmental costs from the outset implies that the burden of costs will be expensed throughout the project ife and thereby the financial burden at the time of closure is reduced. Yec represents the cash low curve which integrates closure costs into operations through the life of the project. As a esult of this integration, the burden on the company at the time of closure is substantially educed. Planning for closure would require that investments in environmental quality be put n place, or allowed for to ensure that at the time of closure the site is rehabilitated and in a hape that is commensurate with the expectations of the community. Investments would nvolve: expenses to reduce pollution at source, i.e., treat pollutants before they are lischarged into the environment and/or adopt a cleaner technology that reduces the amount of ollution that is generated, expenses to clean up the pollution/degradation that occurs nyway; expenses involved in monitoring predicted and unpredicted impacts; expenses nvolved in developing human capacity to initiate and sustain environmental management ractices, and to cope with closure impacts. More specifically, closure will involve ehabilitation of mine pits, rehabilitation of abandoned/closed mines and development of lternate economic activities.

Figure 5.9. Annual field cash flow (net)



YY–Cash flow curve uncorrected for closure costs in a regulated regime
Yec–Cash flow curve incorporating closure costs
Yb–Cash flow curve uncorrected for closure costs put in a resime where closure impacts do not matter

Mine pit rehabilitation

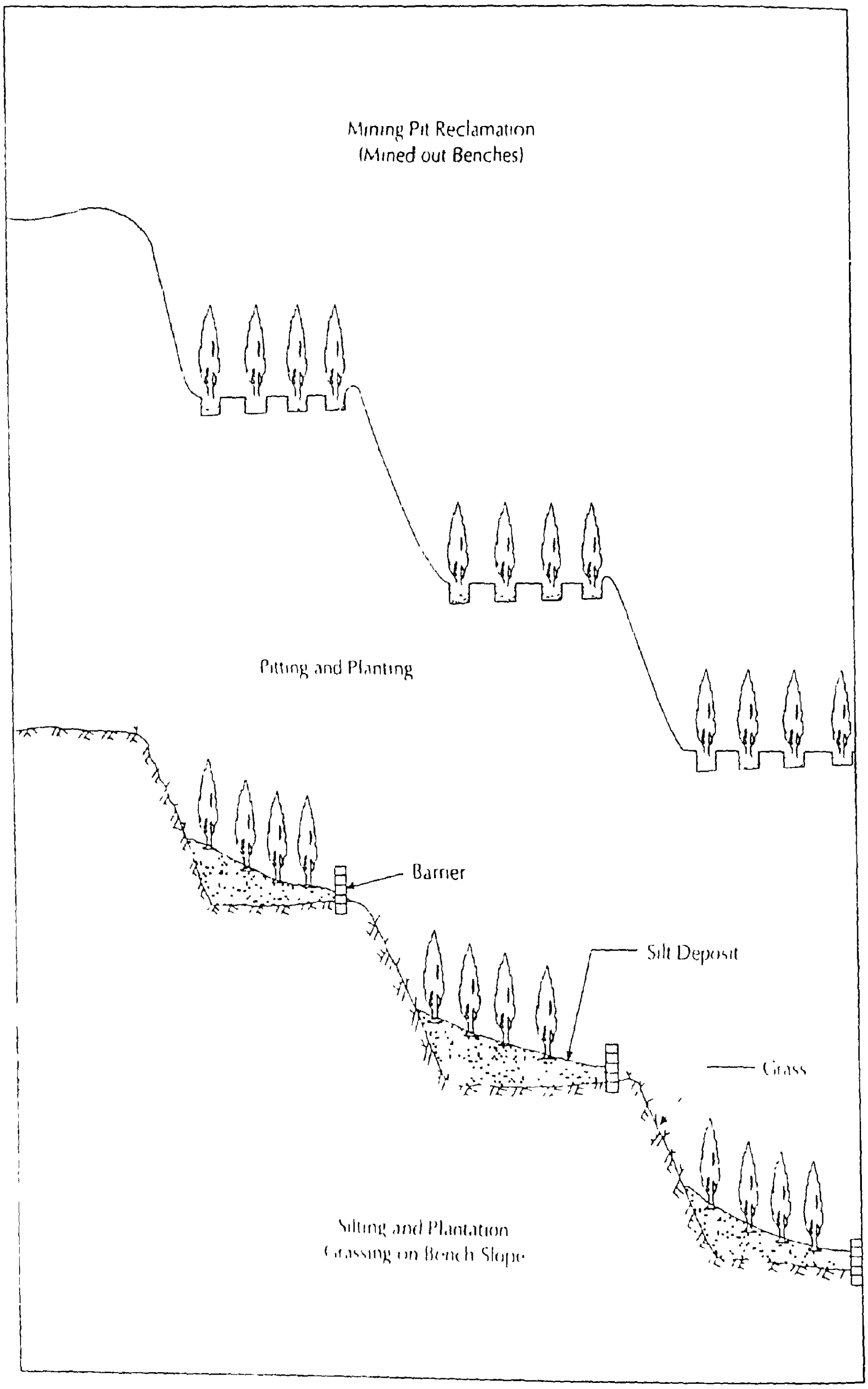
The excavated pits leave a series of benches cascading from top downwards. Apart from natural gravity of the mateial, which is usually taken care of against slips and slumps normally, they do pose serious problems during heavy rains. Adequate rehabilitation of them are thus absolutely necessary. The slopes may be sodded with suitable species of erosion resisting grasses. The benches should be shaped to have mild slope inward preferably with a retention wall of laterite boulders at the edge. This will allow water infiltration on the one hand and, also, accumulation of whatever fine materials get dislodged from the bench surfaces as shown in Figure 5.10. The benches should be planted up with suitable species. This system will be effective in guarding against erosion and also slips and mass flow of materials during heavy rains and eventually form a well-vegetated stable land form. So far this has not been practiced in most of the abandoned mine excavations, but should be rigorously followed for long-run stabilization.

Alternative uses of rehabilitated land

<u>Energy plantation for fuelwood</u>

Fuel, which is in short supply might be obtained on a significant scale from short-rotation crops of shrubs and trees from such rehabilitated sites. Thus, such restored areas become candidate for energy plantation use.

Figure 5.10. Reclamation method for mined out benches



Forestry/horticulture/pasture

Since restoration of damaged land in agriculture is difficult and costly we suggest a multipurpose approach for the development of these areas through forestry, horticulture, pasture and/or their combination. Certain recreational facilities, in addition, may go a long way in improving the landscape of the area. Establishment of forests and horticultural trees, including ornamentals, and pasture, is likely to restore the lost eco-system of these areas, and also accrue good return on sustained basis.

Abandoned pit as water body

The water body so developed may also be utilized for the benefit of the neighbourhood during period of scarcity and also more cultivable waste lands in the neighbouring areas can be brought under cultivation with the help of these water sources. Besides, the water storage can be profitably used for pisciculture which may bring good financial return.

Nature conservation

This is an alternative strategy appropriate to some areas. Since the soil and plants have been removed and all that remained is bare ground and rock, which provides a refuge for plants that cannot stand the competition of the more vigorous plants that grow on good soil. Thus, such plants communities may colonize these restored areas. A wilderness of plants may become a wilderness for animals.

Rehabilitation of closed/abandoned mines

This is based on a study conducted by Ms Vinita Vijayan in the Cudnem/Harvalem mine in North Goa to suggest suitable measures to restore the abandoned mine to an amenity use. In order to facilitate a suitable plan for restoration and rehabilitation, the mining site has been classified into 5 zones. This classification was on the basis of comparative analysis between existing vegetation, soil and topography.

- Zone A - Natural Environment Zone which is the ecologically sensitive area that has to be preserved for the sustenance of the reclaimed land. Recommended activities are undisturbed forest land, nature trail, rock garden, open air theatre.
- Zone B - Intensive Recreational Zone to be developed on land that is partially stabilised by natural means and lies physiographically lower in the project area allowing for it being sustained over time. Recommended activities children play area, angling dock, boating, picnicking, viewing pavilions, cafeteria.
- Zone C - Passive Recreational Zone to be developed on overburden dumps. Once preliminary soil conservation has been achieved, plantation species which promote wildlife habitat should be encouraged. Recommended activities orchard, nature trail, plant nursery, picnicking.

- Zone D - Area for social forestry and agro forestry to be overburden dumps that are already afforested by the mining companies. Essentially this zone serves as a shelter for the landscape development of the site through prevention of dust pollution from neighbouring mines. The existing flat terrain located in this zone is suitable for pasture of livestock. Forest products from this zone could be beneficial for the local communities. Recommended activities fodder and fuel crop, agro forestry and orchard.
- Zone E - Historical and Cultural Zone lies at north western end of the site and is important for its cultural relevance to the local community. Sites of interest Rudreshwar temple, Pandava caves, bhimkund theerth ghats.

The Reclamation of the site is to be done in 3 Phases:

- Phase I - 5 years
- Phase II -10 years
- Phase III - 15 years

For each of the reclamation phases there are related activities which need to be undertaken in each of the zones. These are outlined in the following sections in brief

Phase I

Zone A: Any development in the site is likely to impact on this most sensitive/vital zone of the site. In order to prevent these negative impacts it becomes necessary to adopt certain measures.

- Vegetal method: creating a buffer or hedge plantation which could protect the site.
- Engineering method: design a ditch that runs adjacent to the boundary of the forested area.

Zone B: This is by far the most stable area within the project site and therefore can withstand construction work without major engineering measures

- Grading and leveling: Serves the purpose of erosion control and assists to achieve desired spatial functions and designs.
- Delineation of area for development
- Mark alignment of circulation system
- Shelter belt/buffer plantation
- Clear water bodies of hazards: Introduction of fish
- Establishment of vegetation

Zone C: This zone is most unstable and requires intensive measures to ensure suitable reclamation

- Engineering measures for stabilization: reduce slope gradient and run offs through a series of terraces and diversions.

- Design garland drains along the periphery of the settlement tanks. The water is to be finally diverted into the natural water system after clearing of sediments through mechanical and chemical treatments. Possible mechanical measures which can be adopted are earthen dikes, channels, down drain, settlement tank, filtration tanks.

Zone D: The edge of the reject dump needs to be afforested to prevent erosion, therefore recontouring is required as a initial step. Zig-zag bund has to be constructed along with a retaining wall and series of check dams.

Zone E: Since there is a continuous flow of tourists and local visitors to this area construction should not start during the tourist season.

Phase II

Zone A: Passive recreation areas to be developed along the periphery of the forest land to provide a natural setting for the visitors.

- Lay pathway based on topography
- Create barriers for screening and distance

Zone B:

- Design detailing
- Water edge treatment (lake)
- Maintenance of vegetation: weeding, distribution of vegetation by transplantation and additional plantation

Zone C:

Establishment of vegetation: Install plant cover, grass with fibrous system. Use mulches till grass is established.

Zone D:

- Afforestation of the recountoured areas: Use of grass and legumes
- Plantation for wind breaks

Phase III

Zone A: This area has very limited construction activity and therefore in this phase the area is largely left undisturbed.

Zone B:

- Construction of boat launch
- Maintenance of water edge
- Establish aquatic habitats
- Check water quality

Zone C: This zone would be further divided into 2 stages of development

Stage I (3 years)

- Establishment of vegetation , general seed mix preferred as well as those species which produce biomass.
- Delineate zones for development
- Lay alignment for circulation system

Stage II (2 years)

- Distribute vegetation for transplantation
- Construction of circulation system and other accessory facilities required
- Maintenance

Zone D: Plantation of orchard

Development of economic activities around and beyond mining area

Dump rehabilitation activities

Another potential area for employment of local population in the mining villages is in dump rehabilitation activities. Already some of the companies are employing local people for plantation/afforestation activities. Adopting a scientific approach to the whole issue of rehabilitation of mined areas, as explained in the report could provide employment opportunities and also lead to some economic activities. The method of involving local communities should be worked out in consultation with local people and concerned government agencies. The issues that are pertinent to community dump management are ownership of land, status of the dump and how far it is located from the operating mines. The success of the project is only possible if the community is interested in participation.

Opening of industries

The sector of industries and minerals in fact should provide for bulk employment generation in the state Though the sector contributes substantially to the state domestic product, the estimated employment generation during the 8th plan is only 8.76 lakh mandays, accounting to about 1.3% of total employment generation during the period. An outlay of Rs 36.50 crores was provided by the government for the industry and minerals sector in the 8th plan. This includes Rs 7 crores for village industries viz. I) starting up of tool room cum training center and ii) state subsidy for industrial units and Rs 19 crores for the development of industrial estates and related activities In the mining areas, small and medium industries for food processing, dairy development and engineering units could be promoted under the governments programme. In addition, units to manufacture building blocks from the waste material could be encouraged. The details of an experiment to manufacture building blocks in one of the mines is given below:

Building blocks from waste overburden material

The local community could also be involved in making building blocks from waste material. An experiment is underway in cluster III where blocks are being made with overburden material from Codli mines of Sesa Goa. These are in 2 sizes: 30cm x 20 cm x 15cm with a strength of 40kg/cm2 using 8% cement and a load bearing capacity of ground plus first floor. These cost Rs 4.5-5.00/block and are planned to be sold at Rs 6.50. In this way they compete with normal laterite stones used in local construction which cost Rs 6.00/stone. The reject blocks are more uniform in shape and require less plastering than the regular stones. The blocks are sunbaked and use water for curing. The small blocks or partition blocks are 30cm x 11 cm x 15 cm. These cost Rs 2.50 and are planned to be sold for Rs 4/block. The normal brick is sold for Rs 4.50. However, a partition block covers 3 times the area of a normal brick and uses less cement. It is thus expected to be competitive with the normal bricks. To provide a market for these blocks, the government can come in as a large buyer and use these blocks for Sulabh toilets, new government constructions, etc. It is estimated that 100 big blocks require 3 tonnes of laterite overburden plus 16% sand and 8% cement. This is certainly one venture that needs to be followed more closely., If local people would like to make blocks then the necessary infrastructure that is required for block making has to be provided. Mining companies could provide some financial help for the community but emphasis should be on the community contributing for the project so as to ensure a sense of ownership and responsibility.

Environmental and social cost analysis

Environmental costs

Environmental control measures need adequate funds and efforts to ensure permanent improvements in the status of environment in the study area. The cost of environmental control measures should be an integral part of cost budgeting of all mines. The cost estimates should also provide information on the time horizon over which the costs occur. EMP's are now an integral part of all project reports. However, the EMP prepared for mines in Goa as a part of the mine plan document (submitted to IBM) for renewalof lease do not carry cost estimates for environmental control measures. Based on a number of assumptions, we have estimated the capital cost and operating costs for various control measures listed under MS-1 and MS-2. Capital cost of tenancy land acquired for mining is not included in the environmental cost. In addition, the cost for improved welfare measures in the mining villages (under MS-3) has also been estimated. The broad assumptions used in the analysis are as follows:

MS-1: Planned improvements including additional control measures

Compensatory afforestation

It is assumed that non-forest land equal in area to the forest land acquired would be provided by the State Government for compensatory afforestation. The cost of such land is taken as Rs 1 lakh per ha. Till 1995-96, the state forest department was charging 28000/- per ha. towards compensatory afforestation, but now the department has reported that since the minimum wage rate in Goa has more than doubled, the cost towards compensatory afforestation would increase. We have taken Rs 50000/- per ha as the cost of compensatory afforestation. The total forest land to be released in future for mining in Cluster III and IV is estimated as about 100 ha (Cluster III-65 ha; Cluster IV-35 ha). The costs of acquiring land for compensatory afforestation and afforestation activities are to incurred by the company which acquires the forest land. Their amount is paid to the state forest department.

Land reclamation

For technical reclamation of dumps, dozers would be required. The number of dozers would depend on the amount of levelling and grading work involved and the working norms for the dozers. For a 320 hp dozer, the recommended work load is 0.60 Mm3/a for an average pushing distance of 30 meters and 0.45 Mm3/a if the pushing distance is 45 m. At least 1 dozer should be provided exclusively in each mine for dump management. The biological reclamation work would include establishing drainage, spreading soil where possible, digging pits, planting, fencing, and developing nurseries. A cost of Rs 70000 per ha for land reclamation is assumed. The total land to be rehabilitated is 1152 ha and it is assumed that approximately 80 ha of land would be rehabilitated every year for the next 15 years.

Pollution control measures

(i) For dust control in mines and haul roads, 4-6 water sprinklers should be provided in each mine. The cost of truck with sprinkler arrangement is taken as Rs 10 lakhs. An average of 4 trucks per mine is assumed. The annual operating cost for dust control measures including chemical spraying is taken as 15% of the capital cost.

(ii) Green belts of proper design would be established around mines, screening plants and beneficiation plants and along road corridors. The cost of green belt per running kilometer (10m green belt on either side of the road) is assumed as Rs 50,000/- and the total length of roads is taken as 50 kms (28 kms new road + 22 kms existing road). In addition, an amount of Rs 5 lakhs per year for five years is provided for green belt in mines and beneficiation plant areas.

(iii) Garland drains: Rs 50 lakhs for all mines

(iv) Wheel wash/spray system: Rs 10 lakhs for all mines

(v) Pit water primary treatment before discharge: The details are as under:

a) *Cost Estimation*:The exact quantity of pit water being pumped out by all mining companies is not known. It is estimated that total pit water pumping by all mines will be of the order of 370 Mld. The quantity of water considered under various treatment schemes are given below. All pit water which is pumped out is treated under scheme I before discharge to meet the standards. In scheme II, 50% of the total water discharge is further treated for agriculture and domestic use. In scheme III, 50 Mld of water is further treated in a central tank for providing drinking water to the population in affected villages. The brief details of the schemes and the cost for each scheme are given in Tables 5.10 to 5.12. The cost for scheme I and II are based on experience and likely to vary depending on the local costs.

Table 5.10. Details of water treatment schemes

Scheme	Brief Description	Quantity of water to be considered	Purpose
Scheme I	Lime treatment followed by laterite walls.	320 Mld	to treat all pit water before discharge
Scheme II	Lime treatment followed by laterite wall and filters	160 Mld	For agriculture use
Scheme III	Treatment in a central tank by activated carbon	50 Mld	For potable water

Table 5.11. Cost estimation for units under scheme 1.

Item	Unit cost (Rs)	Quantity	Approximate cost/ 4 Mld pit water (Rs)	Total Cost (Rs Lakhs
Capital cost				
Capital cost of MS tank for lime slurry preparation	45,000/t*	1 2 t	54,000	
Agitator (5 H.P. ; turbine type)	1,50,000	1	1,50,000	
Operating cost				
Pitching of the receiving drain with sandstone till laterite walls	20/ sq mt	1600 m^2	32,000	
Laterite walls	100 / cum	12	1200	
Mixing tank	150 / cum	8	1200	
Annual operating cost of the lime slurry tank				
- Lime	500/t	200 kg/d	36,000/annum	
- Electricity	2.0/KW	90 KW/d	65,700/annum	

* includes the cost of fabrication, erection and painting

Total capital cost for Scheme I = (320/4) x 2,38,400 = Rs 1,90,72,000
Annual operating cost for Scheme I = (320/4) x 1,01,700 = Rs 81,36,000

Table 5.12. Cost estimation for the filtration unit under scheme II.

Item	Unit cost (Rs)	Quantity	Approximate cost/ 4 Mld pit water (Rs.)	Total Cost (Rs Lakhs)
Capital cost for filtration unit	15,000/ sqmt	6.25 sqmt	93,750	37.5
Annual maintenance cost (5% of the civil work)			4,687	1.8

Scheme III The cost of treatment of tank water by activated carbon would include-

a) initial pumping to carbon contactors;

b) initial carbon charge;

c) carbon handling and storage facilities;

d) backwash pumping;

e) backwash water storage basin; and

f) administrative laboratory and maintenance building

The cost of the scheme should be based on proper assessment and design of the system. However, it is estimated that the capital cost of implementing such a scheme will be of the order of Rs 3125 lakhs and the annual operation and maintenance cost will be around Rs 300 lakhs. The costs are taken from the "Handbook of public water systems" by Williams and Culp (See Bibliography).

MS-2:Fugitive dust reduction on roads and alternate roads for ore traffic

It is assumed that strengthening and widening of existing roads would be spread over 5 years and the construction of alternate roads (20 kms) and bridge for South Goa mines would also be completed in 5 years. The details of the lengths of road and capital cost and O&M cost are given in Table 5.13. The cost estimates are indicative only and are based on discussion with concerned agencies.

Table 5.13 Cost details for roads

Type of roads	Length (km)	Capital cost (Rs lakhs/km)	Total capital cost (Rs lakhs)	O&M cost @ 2 5% (Rs lakhs)
Mine road	50	50	2500	62
Public roads	120	75	9000	225
Alternate (new) roads + bridges	20		4200	105

MS-3: Measures to alleviate societal problems affecting mining villages

The following assumptions are made for welfare measures.

Potable water supply

The capital cost is estimated at Rs 3125 lakhs and operating cost is Rs 300 lakhs per annum. It is assumed that the central water treatment plants would be constructed in two years.

Health facilities

Rupees 20 lakhs per village for three villages where PHC is not provided.

Sanitation facility

Rupee 1 lakh per village

Vocational training institutes

Rupees 15 lakhs per institute one in each cluster.

Summary of capital requirements and cost analysis

MS-I

The total capital investment required is estimated at Rs 4509 lakhs. The operating costs are estimated at Rs 5200 lakhs over the 15 year period. Out of this, the company's have already invested some amounts on dust control measure, garland drains, etc. However, we are ignoring these amounts in our analysis to arrive at the estimated cost of control measures on the ore production. The total cost has been discounted at 12% to arrive at the net present value (NPV). The ore production is taken as 14 Mt per annum for the 15 years period and this has also been discounted at 12%. Based on these, the cost of control measures under MS-1 works out to Rs 7 per tonne of ore production. The details are given in Table 5.14.

MS-2

This is essentially to improve the road condition in the mining area including alternate new roads in South Goa. The total capital investment is estimated at Rs 15700 lakhs. The O&M expenditure increases from Rs 287 lakhs to Rs 392 lakhs per annum when new roads are completed. The total cost has been discounted at 12% to arrive at the NPV, and the impact of the cost on ore production works out to Rs 14 per tonne. If we exclude the alternate (new) roads from the analysis, the total capital investment is estimated at Rs 11500 lakhs and the operating cost would be Rs 287 lakhs per annum. The impact on the cost of ore production is Rs.11 per tonne. The details are given in Table 5.14.

S-3

ıder the welfare measures the major expenditure is on pit water supply after treatment to 'ected villages. The total capital cost is estimated at Rs 3275 lakhs and the operating cost is imated at Rs 310 lakhs per annum. The impact of the cost on ore production is about Rs 5 r tonne. The details are given in Table 5.14.

ιising resources

S-1

ιe investment costs for pollution abatement measures are part of the production operations d the mining company should absorb these costs. Regarding investment for land :lamation in old and abandoned dumps, the government can provide some funds to the rest department or to the affected community.

S-2

the 8th plan, the state government had provided an outlay of Rs 1223 lakhs towards ıprovement and widening of existing district roads and Rs 219 lakhs for mine roads. Since ɛ outlay is too meagre, the condition of roads has not improved. In addition, alternate roads ve been proposed for ore traffic from South Goa mines. The government can raise sources either through budgetary provision or by charging a road cess on iron ore. If the full ıount is charged on iron ore, the impact on cost is Rs 14 per tonne. If the new roads are cluded from the analysis, the impact on the cost of ore production is Rs 11 per tonne. ıerefor the government can charge a road cess on iron ore ranging between Rs 11 to Rs 14 r tonne. The higher cess would recover some of the cost of alternate roads to be nstructed.

S-3

nder the welfare measures, the major cost is for providing drinking water to the affected llages. The impact of welfare measures cost on ore production is Rs 5 per tonne and this can : recovered in the form of a social welfare cess from the companies.

Table 5.14. Cost analysis for different strategies

All figures in Rs Lakhs except ore production in Lakh tonnes

MANAGEMENT STRATEGY 1 - PLANNED IMPROVEMENTS	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Capital Costs															
Land for compensatory afforestation	10	10	10	10	10	10	10	10	10	10					
Land rehabilitation: equipment costs	1500	1500													
Dust Control: water sprinklers	1200														
Wheel wash/spray arrangement	10														
Garland drains	50														
Pit water primary treatment	191														
Pit water secondary treatment	38														
Total investment	2999	1510	10	10	10	10	10	10	10	10					
NPV of investment at 12% discount factor	4391 6														
Operating costs															
Compensatory afforestation	5	5	5	5	5	5	5	5	5	5					
Land rehabilitation	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Dust control	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
Green belt development	10	10	10	10	10										
Wheel wash/spray	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Garland drains and erosion control	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Pit water primary treatment	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82
Pit water secondary treatment	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Monitoring	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Total operating cost	355	355	355	355	355	345	345	345	345	345	340	340	340	340	340
NPV of operating cost at 12% discount factor	2665 6														
Total cost at NPV	7057 2														
Production of ore	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
Discounted production	1067 9														
Cost Rs per tonne of ore MS-1	6 6082														

All figures in Rs Lakhs except ore production in Lakh tonnes

MANAGEMENT STRATEGY 2 - ROAD	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	[illegible]
Capital Costs															
Mine roads	500	500	500	500	500	0	0								
Public roads	1800	1800	1800	1800	1800	0	0								
New roads	840	840	840	840	840	0	0								
Total investment	3140	3140	3140	3140	3140	0	0								
NPV of investment at 12% discount factor	12677														
Operating and maintaining costs															
Mine roads	62	62	62	62	62	62	62	62	62	62	62	62	62	62	
Public roads	225	225	225	225	225	225	225	225	225	225	225	225	225	225	
New roads		21	42	63	84	105	105	105	105	105	105	105	105	105	
Total operating cost	287	308	329	350	371	392	392	392	392	392	392	392	392	392	
NPV of operating cost at 12% discount factor	2716 8														
Total cost at NPV	15394														
Cost Rs per tonne of ore MS -2	14 415														
MANAGEMENT STRATEGY 2 - WITHOUT NEW ROAD															
Capital Costs															
Existing roads	2300	2300	2300	2300	2300	0	0								
NPV of investment at 12% discount factor	9285 9														
Operating and maintaining costs															
Existing roads	287	287	287	287	287	287	287	287	287	287	287	287	287	287	[illegible]
NPV of operating cost at 12% discount factor	2189 3														
Total cost at NPV	11475														
Cost Rs per tonne of ore Only new roads	10 745														
MANAGEMENT STRATEGY 3 - SOCIAL															
Capital Costs															
Pit water treatment for drinking	1500	1625													
Education and health facilities	60														
Sanitation	30														
Training Institute	60														
Total investment	1650	1625	0	0	0	0	0								
NPV of investment at 12% discount factor	3100 9														
Operating Costs															
Drinking water		300	300	300	300	300	300	300	300	300	300	300	300	300	[illegible]
Others	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Total operating cost	10	310	310	310	310	310	310	310	310	310	310	310	310	310	310
NPV of operating cost at 12% discount factor	2064 7														
Total cost at NPV	5165 6														
Cost Rs per tonne of ore MS -3	4 837														

Impact of MS-4 on the cost of iron ore production

The average costs of the mining industry is reported as follows:

Table 5.15. Average costs (Rs per tonne)

Heads	Lower limit	Upper limit
1. Pit head	60	125
2. Processing	33	45
3 Truck transport *		
(Rs/t) North Goa (avg)	9	18
South Goa (avg)	60	60
4.Barge costs	30	40
5 Port charges	46	46
6 Royalty, cess	9	9
7 Environmental control	0.5	1
Total	187 (North Goa) 208 (South Goa)	284(North Goa) 326 (SouthGoa)

* Note North Goa average asssumes trucks travel between 5-10 km to LP and are paid Rs 1 80/tonne, South Goa average assumes travel between 15-30 kms to LP and average amount of Rs 2/tonne km

It can be seen from the table the (upper limit) cost vary from Rs 284 to Rs 326 per tonne for North and South Goa respectively. Taking the average cost as Rs 300 per tonne of ore, the environmental control costs (under MS-1), which is Rs 7/tonne would be about 2.3% of the average production cost. This cost can be absorbed by the companies For MS-2 and MS-3 the total cess on iron ore would be Rs 19/tonne (road cess Rs 14 + social cess Rs 5) which is about 6.3% of the average production cost. For all the three strategies together which can be taken as MS-4, the total cost is Rs 26 per tonne and the impact would be 8.6% of the production cost.

Management strategy evaluation

There are definite environmental benefits of adopting strategies MS-1 and MS-2. The benefits are a reduction in dust levels leading to improved air quality; drastic reduction in suspended solids in the discharge of mine water and storm water runoff and tailing ponds, and less damaged land in the area. Population exposed to high dust levels is drastically reduced in the mining villages and road corridors. It has not been possible to quantify the benefits in monetary values and/or the reduction in incidence of diseases, etc. There is an overall improvement in the environmental quality of the area.

The improvements in the existing roads and diversion of ore transport from South Goa mines through new roads would result in less traffic congestion, reduced accidents and substantial reduction in fugitive dust levels in the area. The improved roads would also cater to additional freight and passenger traffic leading to economic gains for the state.

The social welfare measures under MS-3 would result in significant improvement in the quality of life of the population in the mining villages. Pit water supply arrangement if implemented, can a long way in meeting the water demand, especially during summer months. The training institutes would open up employment opportunities for the local villagers by upgrading their skills.

Planning for closure of mines from the outset under MS-4 would result in creating alternate economic activities in the area which would benefit the population likely to be affected by the closure. In addition the rehabilitated mined land would be used for productive purposes such as growing cash crops fuel wood, etc. and for recreational facilities.

Annexure 5.1. Recommended trees for the dumps

Plant Name	Characteristics	End use
Fast growing plants *Glyricidia*	Fast growing shrub with lots of leaves	Fodder and provides good leaf manure
Leucaena leucocephala (subabul)	Leguminous tree, grows well in laterite soils. Good soil binder	Fodder, firewood and charcoal
Alstonia scholaris (saton, satvin)	A fast growing large evergreen tree	Primary wood used for coffins and false ceilings
Eucalyptus (nilgiri)	A fast growing tall evergreen tree	Timber, construction poles, oil used for phamaceuticals
Casurina equisetifolia (suru)	Fast growing tall straight tree 1-2 years sapling can be replanted	Fuelwood, timber, poles for construction
Acacia nilotica (babul)	Moderate sized fast growing tree	Timber,firewood and medicinal
Ficus hispide (karoti, kharvont)	A small tree (10m) grows well in disturbed soils.	Firewood
Buchananea latifolia (charam)		Timber, fuelwood, berries are eaten and leaves used for plates
Slow growing plants *Bauhinia vareigate* (Apte kachnam)	Slow growing leguminous tree useful for soil improvement	Fuelwood, timber and fodder
Anacandium occidentale (cashew)	Widely spreading tree suited to laterite soils, can be grown anywhere on the dump	Cashew apple used to produce liquor Nut is eaten and shell yields wood preservative used in paints
Acacia catechu (khair, katho)	Indegineous variety grows to a modertae height	Katha extracted, fuelwood, and bark used for tanning
Albizza lebbek (siris, siros)		Timber and fuelwood
Bombox ceiba (savor, semul silk cotton)	Fast growing tall tree suited for laterite soils	Timber and fuelwood
Cassia siamea (kassod)	Medium sized leguminous tree useful to improve soil quality	Timber, fuelwood and fodder
Anacandium occidentale (cashew)	Widely spreading tree suited to laterite soils, can be grown anywhere on the dump	Cashew apple used to produce liquor Nut is eaten and shell yields wood preservative used in paints
Azadirachita indica (neem)	Slow growing shady tree with bitter leaves	Medicine, timber, fuelwood

Plant Name	Characteristics	End use
Syzygium cuminii (jamun)	Tall tree with purple fruits	Edible fruits, fuel and timber
Garcinca indica (binna, cocum)	Medium sized tree that grows well in laterite soils	Fruit edible also used to make juice
Terminalia bellirica (goting, baheda)	Tall tree with fruits that contain oil.	Timber, fuel and medicine
Rauvolfia serpentina (adki, sarpa gandha)	Small shrub which is on the list of endangered plants	Medicinal
Lannea coromandelica (moi, ganjan)	Large deciduous tree	Timber, fuelwood

CHAPTER 6

Improved environmental behaviour: The institutional dimensions

Introduction

The state of the environment in the mining belt of Goa is a cause for concern and there is need for some urgent remedial action as well as the need to ensure that companies adopt better mining practices in their current and future mining operations. The study revealed that there is some amount of environmental management practices already adopted by the five large mining companies in the region, but there is little regard for environmental issues by the smaller mining companies. Even among the five large mining companies, it is observed that the level of environmental management differs among operating mines, with some mines being managed better than others. Moreover, environmental management has not been adopted from the outset, but has been a process of incremental additions to control equipment and better practices as degradation problems arose, regulations became more widespread and general popular pressure against environmental damage began to grow in Goa. Again the extent to which mining companies have been proactive even within this limited set of practices has been largely influenced by company specific factors such as corporate culture, managerial leadership, the desire to appear green, and exposure to local pressure for better practices.

It is a well recognized fact today that institutions- constellation of rights, rules and relationships that define social practices and guide interactions among those involved- are important in understanding both the drivers of environmental change and responses to such changes. A study of all the institutions that shape the environmental behaviour among the mining companies is a study on its own. In this chapter, we limit ourselves to one important category of institutions - regulatory arrangements and their implementation. We conclude by making concrete suggestions for improving the environmental behaviour of mining firms.

Regulatory arrangements

The environmental protection provisions contained in mining laws

The major act regulating mining activity is the Mines and Minerals (Regulation and Development) Act (MMRD) promulgated in 1957 and the Rules made this Act. This Act was amended in 1986 in order to incorporate provisions relating to environmental protection. Similarly, the Mineral Conservation and Development Rules (MCDR) were amended in 1986 as a need was felt to

oroughly revise these rules to take into account the new requirements necessary for systematic and ientific mining as well as to incorporate provisions relating to environmental aspects after the overnment had acquired powers to make rules by virtue of the amendments made in the parent act. ccordingly, the new Mineral Conservation and Development Rules were notified by the overnment of India in 1988. The National Mineral Policy announced in 1993 outlines the direction which it was desired to develop the mining industry and the priorities for actions to be taken in lation to various aspects related to mining and development of mineral deposits including aspects f environmental protection. To implement the objectives of this policy, some changes were effected the MMRD Act and the MCDR. Every holder of a prospecting licence or a mining lease has to ke all possible precautions for the protection of the environment and control of pollution while gaged in prospecting, mining, or processing in an area. Changes to accommodate environmental ifeguards were also made in the Mineral Concession Rules (MCR), 1960 which regulate the grant f mining leases in the country. Apart from specific environmental provisions in the Mining gislation, there are strong environmental laws that regulate economic activity in the country. The ection below discusses these and then relates them to the institutional functioning in Goa.

he environmental law framework

here are four main statutory acts that regulate environmental impacts from mining activity:

The Water Pollution Act 1974 is comprehensive in its coverage, applying to streams, inland waters, ground waters, and sea or tidal waters. It vests the authority in State Pollution Control Boards to establish and enforce effluent standards and the quality of receiving waters. Prior to amendment in 1988, enforcement under the act was achieved through criminal prosecution After 1988, the authorities can close down a defaulting unit or withdraw infrastructural support services if found to be transgressing. A person must obtain consent from the state board before taking steps to establish any industry, operation or process, any treatment or disposal system which might result in the discharge of sewage or trade effluent into a stream, well or sewer or onto land. (Sec 25) Section 26 of this Act requires that persons releasing water pollutants prior to the adoption of the Water Act must also meet the requirements of Section 25

The Air Pollution Act, 1981 is similar to the water act. It is an act to provide for the prevention, control and abatement of air pollution It lays down air pollution standards and is administered by the State Pollution Control Boards. It also empowers the authorities to close down an unit or to withdraw support services if found violating the law. This act grants government discretion to each state government to designate particular areas as 'air pollution control areas'. According to t

- *The Forest (Conservation) Act, 1980* prohibits state governments from allotting any forest land, or any portion thereof for any non-forest purpose without approval from the Central Government. It is a central act applying to the whole of India, other than the state of Jammu and Kashmir. Approval of the Central Government is necessary for a mining lease to be granted in respect of any forest area; for the resumption of mining operations on the expiry of a mining lease; for information relating to rehabilitation of mine sites, damage to trees, distance of the site from important ecosystems and highways, reclamation procedures, and extent of subsidence expected in underground mines when proposals are made to divert forest land to non-forest use. Compensatory afforestation is one of the most important conditions stipulated by the Central Government while approving proposals for dereservation and diversion of forest land.
- *The Environment Protection Act, 1986* is applicable to the whole of India and overrules other legislation, including local laws. Under Section 5, it grants government the power to close down any industry if found violating the law. Consequent to the Act, the Environment Ministry has, among other requirements, laid down the following:
  - the standards of emissions for the discharge of environmental pollutants,
  - procedures and safeguards for the prevention of accidents,
  - requirement of a mining plan inclusive of an environmental management plan from mining companies. The EPA notification of 1994 requires that all mining activity involving more than 5 ha obtain an environmental clearance from the MoEF when a new project is being considered or an ongoing project is being expanded or modernized. According to the MoEF, when a mining plan makes mention of breaking new ground that was not provided for in an older plan, it amounts to expansion of activity, and hence needs an environmental clearance from the MoEF.[1]

State laws

Many state level acts are also powerful instruments for environmental management. For example, the Town and Country Planning Act 1973 regulates urban and regional development and controls land use. Municipal acts have numerous clauses relevant to environmental concerns. The Irrigation Act of 1973 under section 84 makes it an offence to corrupt or foul the water for any canal so as to render it less fit for the purposes for which it is ordinarily used. More recently the Goa Panchayat

[1] To obtain an environmental clearance from the Ministry of Mines and the MOEF, a company has to submit (i) a detailed questionnaire or checklist of impacts and (ii) and an environmental management plan and/or an environmental impact statement. On 10th April 1997, the EPA 1986 was amended through a notification to include the process of public hearing for the grant of environmental clearance to any new project or expansion/modernization activities. These hearings are to be coordinated by the State Pollution Control Boards (SPCBs)

Raj Act 1993 under section 88 empowers the Village Panchayat to penalize anyone found defiling water that is set apart for drinking purposes.

From the discussion on laws, it is evident that the Government has four main instruments of control to regulate the environmental impacts of mining activity:

1. The potential for a lease to be terminated under the MMDR if found to be harming the environment (MMDR Act sec 4A(1)).
2. The Mining plan, a sine qua non for granting the lease which incorporates an Environmental Management Plan (MMDR Act sec 5.2(b)).
3. The Environmental Clearance from the MOEF for new projects and the expansion of old projects if the area involved is more than 5 ha. (EPA notification 1994).
4. The `consent to establish' and the `consent to operate' which gives operational control to the SPCB to regulate point source pollution (Water Act 1974 Sec 25).

These main instruments of direct control are supported by other state acts discussed above. The section below discusses the use of these instruments of control to protect the environment in Goa.

Operationalizing the instruments of control

Grant/Renewal/Termination of mine leases

The MMDR is a very strong act and can be a powerful instrument in the hands of the Central government to regulate the environmental behaviour of mining companies. The State Government derives its powers from the Mineral Concession Rules 1960 framed by the Central Government under section 13 of the MMDR. These Rules lay out very clearly the conditions under which a lease may be granted, renewed, and terminated. Under section 4 A of the MMDR, the Central Government after consultation with the State Government, may request the latter to make a premature termination of a mining lease if it is of the opinion that it is expedient in the interest of regulation of mines and mineral development, preservation of natural environment, control of floods, prevention of pollution, or to avoid danger to public health or communication or to ensure safety or buildings, monuments or other structures or for conservation of minerals resources or for maintaining safety in the mines. The threat of terminating a lease on grounds of poor environmental practices is a powerful stick that can be used to get companies to adopt better mining practices. It has however never been used in Goa. Neither has the power the Government has to declare that a lease has lapsed when it has not been operated for more than 2 years ever been used. This is evident from the fact that the number of leases that have been granted are much higher than those that are actually working. From the

information collected from the Department of Mines, there were 116 leases that had been granted and in force in the 4 clusters, and of these only 44 were actually being operated in 1996.

The granting and the renewal of mine leases for iron ore in Goa are done by the State Government through its Department of Industries and Mines. This clubbing together of two important departments is one of the singular most important reasons why this Department has not been a more proactive department. The Department is forced to play second fiddle to the needs of industry and thus is often short of manpower, equipment and skills. One of the main constraints that the Mines Department faces is the absolute lack of co-ordination that it has with other government agencies dealing with mining companies. Hence it has very little information upon which to base any decisions relating to mine leases. A management information system is non-existent. Although it deals with an industry that is supposed to be important to the Goan economy, the department does not even have production data easily available or in a computerized form. The retrieval of data is a time consuming and laborious process, quite quaint in this information technology age. It is absolutely essential to introduce computers and computer literate staff not only to improve processing capacity, but to use it as an opportunity to redefine the information system. Reporting procedures need to be simplified and accelerated; there is need for information flows between departments in order to ensure a system for evaluating the consequences of different types and levels of mining activity.

The Mines Department, through its Senior Technical Assistant, does play an active role in promoting environmental studies on the following:

- Revegetation practices.
- Control of pollution at Khandepar river and Saluali reservoir during monsoon.
- Organization of water for Opa water works by pumping the water from mining areas during month of April and May.
- Manufacture of bricks and blocks out of mining rejects.
- Study of mining rejects for its utility including trace elements in co-operation with geological survey of India.
- The use of water from the mining pits for irrigation.
- Development of pisiculture in pits.
- Landscaping of mining areas for reuse of the area of the mining.

In order to ensure that sound environmental practices are implemented it is important that the approval system for mining leases include the following conditions:

- Compliance with national and local environmental standards.
- Implementation of the approved EMP included in the Mining Plan and also that cleared by the MOEF.

- An Environmental Monitoring programme, the results of which are reviewed by relevant government agencies with a provision for a review of the EMP if necessary.

The mining plan

The MMDR Act requires that mining leases be granted only when there is a duly approved Mining Plan. Further, under Rule 22 A of the Mineral Concession Rules 1960, mining operations have to be undertaken in accordance with this mining plan. For the purpose of approval of the Mining Plan, the Controller General and the Regional Controller of Mines have been declared by the Central Government as the Competent Authority. This plan has to be approved and enforced by the Indian Bureau of Mines. Prior permission of the IBM has to be obtained before abandonment of a mine. A plan for closure is required as a part of the Mine plan. Once all mining operations are ceased the mine company must rehabilitate the mined out area.

The main functions of the IBM are thus to ensure that the mining plan is in accordance with its norms and guidelines. Once the IBM has approved the mining plan, the operator has to ensure that the plan is followed. The IBM has certain guidelines which the mine plan has to meet while drawing up a plan. The mine plan has to contain details of location and height of dumps, method of disposal of tailings or waste from processing activities, mine water drainage etc., which have to follow the IBM norms and guidelines as part of routine good practice mining. When these basic mining practices are not followed there are environmental problems due to "unscientific mining" As a number of problems in the mining belt in Goa are due to bad location of dumps, the direct discharge of mine water and effluents into streams and water bodies, it only follows that mine companies in the state have not been following the mining plan, or else some of the approved mining plans do not contain good practice mining Two questions can be posed here for which the answers are not clear:

1. Are mining companies in Goa submitting Mining Plans that are not as per the norms and guidelines of the IBM, in which case its approval by the IBM needs to be questioned
2. If they are as per the guidelines of the IBM, are they being followed? If they are not being followed as suggested by the IBM itself. why is no action taken against them, either by the IBM or the Department of Mines, both of whom are empowered to act if the Mining Plan is not being followed Mining Leases are given/approved on the basis of the Mining Plan submitted to the IBM and therefore both IBM and the Department of Mines have the power to shut down/cancel leases based on the argument that conditions in the Mining Plan upon which the lease was granted, are not being followed.
3. Chapter 13 of the Mining Plan is an Environmental Management Plan.. The study team did have occasion to see some of the EMPs that have been submitted to the IBM as part of the

Mining Plan and it is evident that these leave much to be desired. The responsibility again lies with IBM to see that the quality of EMPs are improved.

Enforcement of EPA Act and other environmental Acts and Rules

The nodal agency between the Government of India and the State Government on matters relating to the environment is the Department of Environment. Amongst its various responsibilities, it is required to handle various cases and issues under the purview of the EPA 1986 and various rules/notifications published under the same, and to render appropriate advice and/or support to various government departments at their request on environmental issues. It is evident, however, from the list of activities provided to the study team by the Department that it functions essentially as an advisory, promotional and administrative agency rather than as an enforcement agency. It is perhaps, important that the role of this agency be clearly established, although 9 years late, as in its absence, there is no agency in Goa that implements the EPA 1986. However, the Environment Secretary did inform the study team, that the Department does have a clear role to play in the monitoring of environmental impacts and in implementing the relevant laws. That while the IBM is responsible for activities within the mine lease, the impacts that occur outside the lease due to mining operations need to be monitored and regulated by the Department of Environment.

'Consent to establish' and 'Consent to operate'

Under the Air and Water Acts, the State Pollution Control Boards have a lot of power. The following is the list of functions as per these Acts which are relevant to this study.

- Prevention, Control or abatement of pollution of streams and wells in the State
- To advise the State Government on any matter concerning the prevention, control or abatement of water pollution and air pollution
- To collect and disseminate information relating to water pollution and the prevention, control or abatement.
- To encourage, conduct and participate in investigation and research relating to problems of water pollution and prevention, control or abatement of water pollution and air pollution.
- To evolve efficient methods of disposal of sewage and trade effluents on land.
- To plan a comprehensive programme for the prevention, control or abatement of air pollution and to secure the execution.
- To collect and disseminate information relating to air pollution.
- To inspect at all reasonable times, any control equipment, industrial plant or manufacturing process and to give any order such directions to such persons as it may consider necessary to take steps for the prevention, control or abatement of air pollution.
- To inspect air pollution control areas at such intervals as it may think necessary.

- To lay down in consultation with the Central Board and having regard to the standards for the quality of air laid down by the Central Board, Standards for emission of air pollutants into the atmosphere from industrial plants and automobiles or for the discharge of any air pollutant into the atmosphere from any other source.
- To advise the State Government with respect to the suitability of any premises or location for carrying on any industry which is likely to cause air pollution.
- To perform such other functions as may be prescribed or as may from time to time, be entrusted to it by the Central Board or the State Government.

However, to give teeth to a number of these functions, the SPCB has to monitor activities. To do so the Water Act requires that all activities that will be discharging effluents into the water bodies need to obtain 'Consents to Establish' and 'Consents to operate'. Further, the state of Goa has been declared as an air pollution control area by the SPCB. Hence consents to discharge emissions into the air are also required. The study team discovered that except for those mining companies who operate beneficiation plants, and one other mining company, no mining company has obtained these 'Consents to Operate' although they are required to do so. The consent letter requires the SPCB to undertake monitoring of the environment of the water in the pit periodically over the 2 years that the consent is valid after which the company has to renew its consent letter. Besides the company is expected to provide details of water quality to the SPCB every month. No consent letters has led to no monitoring by the SPCB.

The section that follows discusses the other agencies, rules and regulations that should aid the process of environmental management in the mining belt.

The 'safety aspects'

The Regional Director Office of the Directorate General Of Mine Safety (DMS) in Goa has the responsibility of reducing the risk of occupational diseases and casualty to persons employed in mines. The DMS functions under the Mines Act and its jurisdiction applies strictly to the operations within the mine lease and to people employed in the mines. As per the laws the IBM is required to send the mine plans to the DGMS office for comments on the safety measures outlined in the plans The Department is responsible for ensuring that the areas around excavation sites are safe for the people working in the mines. To some extent it is also responsible for the problems that may arise due to mining for the population living in close proximity of the mine i.e. problems related to blasting, and dumps located too close to settlements. The Department has the powers to prohibit or bring about closure of the mine if safety conditions are not met. More recently, DMS has been promoting the concept of 'worker participation in safety management' and 'self regulation', in order to change the emphasis from compliance through legal sanctions to safety through promotional

Mines as to who is operating these leases, this makes it difficult for the DMS to know which entity should be held responsible in the event of contravention as the DMS does not have a record of the actual mine operators. If for various economic and technical reasons it is necessary for mine companies to operate leases that do not belong to them, it is best that the Department of Mines regularize this to enable better monitoring of activities.

'Greening and de-greening' of the mining belt

As discussed earlier, minerals occur in forest areas in Goa, so deforestation is an inevitable consequence of mining activity. With the Forest Conservation act 1980, all activities that involve forest land need to be cleared by the MOEF. The first stage of the clearance process is the Department of Forests in Go. The main functions of the Department, both generally or specifically connected to mining activity are:

- The Department enforces the Forest Conservation Act, 198 0
- Felling of trees from private areas is strictly regulated under provisions of Preservation of Trees Act introduced in 1984.
- Plantations are raised in forest areas
- Maintenance of experimental and sample plots.
- Afforestation of Mine Dumps.
- Compensatory afforestation in degraded forest in lieu of forest land diverted for mining.

The Department of Forests does play an effective role in preventing deforestation and to that extent the Forest Act applies in force. However, the Forest Department has not taken a proactive role in helping mining companies to arrive at innovative dump revegetation programmes which could perhaps reduce rainwater runoff, keep end-uses in mind and involve the local community. What is observed is a 'minimalist attitude' to the operations of the mining company. What is needed is a radical change in the afforestation programmes followed by the forest department. Especially on leases that are non-private, the Department should promote 'community driven' plantations on dumps, with the Department providing the technical services wherever possible. To create this reorientation in the Forest Department will require some amount of retraining and perhaps change in Department manuals.

'Creeping expropriation'

One of the main external effects of mining activity discussed in Chapter 3 was the silting of fields and of irrigation canals thereby resulting in loss of land and/or reduced productivity for the farmers. This amounts to a 'creeping expropriation' of the farmers and others who are dependent on the streams for various uses, as they are pushed out of activities that they have been customarily engaged

in. The loss of agricultural productivity does quite often result in these lands being good for nothing other than for dumping of mine waste, thereby causing a de facto change in land use. There are three government agencies that have a role to play here. The Department of Irrigation which becomes of immense relevance in the context of mining activity in Goa because it occurs in a region which is crossed by rivers, streams and canals, which fall under the jurisdiction of this Department. The silting of such canals can reduce the availability of water for irrigation purpose and/or cause floods upstream. This Department has the responsibility to ensure that this does not happen. Under the Irrigation Act of 1973, section 84 lays out clearly that any impacts on the quality or the volume of the water in the canals which renders it less fit for the purposes for which it is ordinarily used is an offence under the Act. This Department needs to co-ordinate with the Department of Agriculture to ensure that impacts due to siltation are kept to a minimum. Moreover, the Department of Agriculture needs to ensure that the base line crop productivity studies around the mine area become part of the required EIA, so that in the event of siltation that may occur due to unavoidable circumstances, both the mining company and the farmer have a basis upon which to fix the amount of compensation to be paid. The Department of Town & Country Planning also has a role to play here to ensure that mine companies do not allow siltation to occur in order to create a *fait accompli* in changing the land use, bypassing the required route to bring about the same.

Falling by the wayside

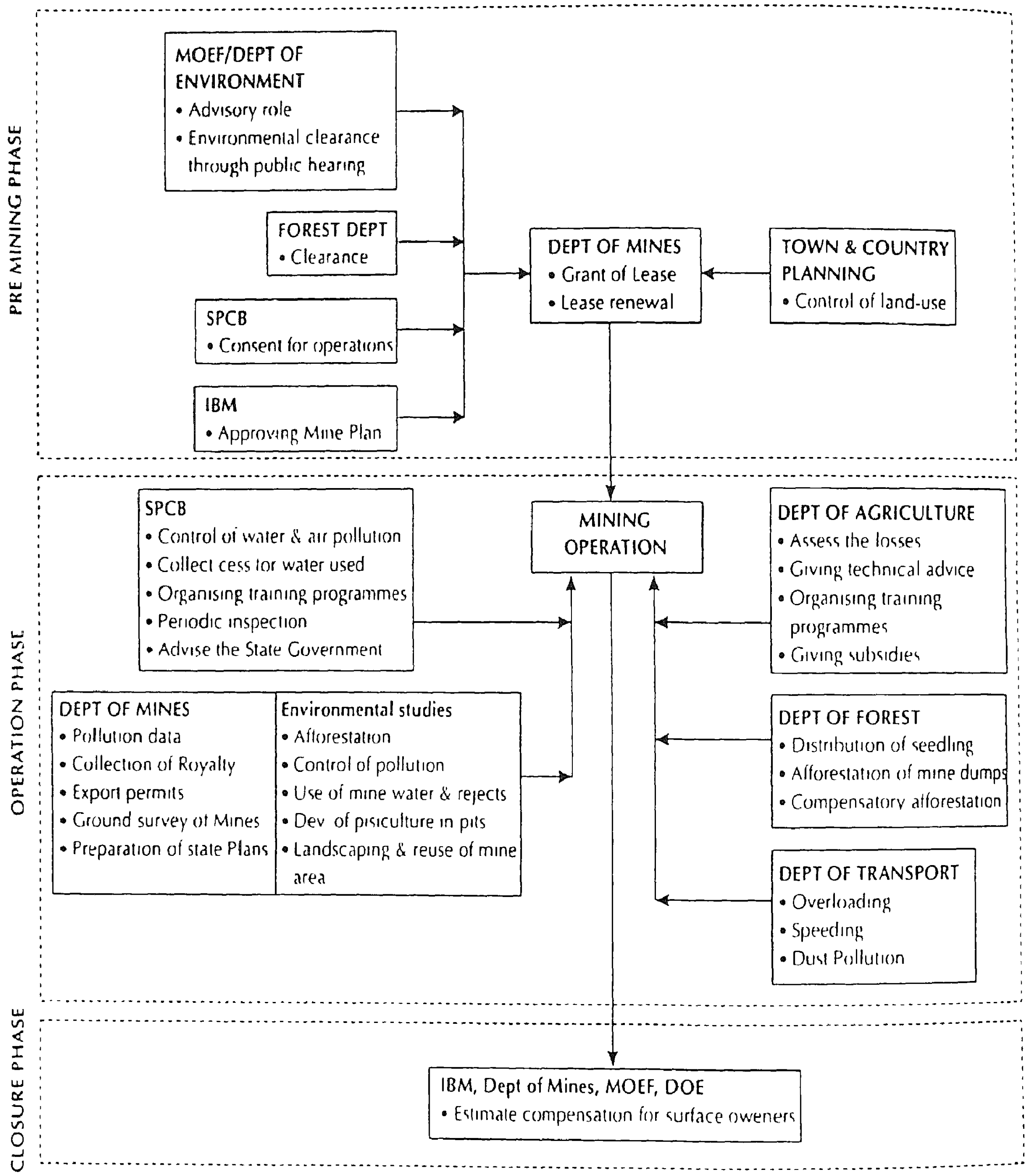
One of the most serious problems of the mining belt is the dust pollution caused by the overloading of ore carrying trucks. Investigations as to who needs to check this, point to the Department of Transport under the Motor Vehicles Act. The trucks carrying ore have a rated capacity of 10 tonnes. However, this is observed more in the breach. The loading of trucks range from around 13-18 tonnes, an overloading of about 3-8 tonnes more than the rated capacity. All the Departments that we spoke to point to their incapacity to do anything about this or the fact that trucks off-load ore by the side of the road when they have a breakdown. The Department of Transport's absence in the region is conspicuous. The Department points to its inadequate staffing to explain why it cannot check offenders in the region. A major short coming of this Department is the absolute lack of a compiled data base on the growth of transport in Goa. We strongly recommend a computer with computer literate staff to help the Department put all the information from its Regional Offices together to enable easy access and retrieval of the data.

Table 6.1 below summarizes the main Acts, the instruments of control and the agencies responsible for their implementation. Figure 6.1 gives the existing linkages and responsibilities of the different departments connected with mining in Goa.

Table 6.1. Relevant regulations - enforcement status in the mining area

Empowering legislation	Main instrument of control	Implementing agency in Goa	Comments
MMRD, 1957; MCR, 1960	Grant/renewal/termination of leases	DEPT. OF MINES	Prerogative not exercised
MMRD, 1957, MCR, 1960, MCDR, 1987	Mining plan, which includes an EMP	IBM (Central Govt)	No monitoring of EMP, Mining Plan. Action taken only if brought to notice by third parties
Air and Water Acts, 1981 and 1974	Consent to establish and operate	SPCB	No consents obtained by operators
Motor Vehicles Act	Check Overloading, speeding	DEPT. OF TRANSPORT	Weak enforcement due to understaffing
EPA, 1986 AND FCA, 1980	Environmental clearance of expansions/modernization, new mines site clearance	MOEF (Central Govt)	In Goa, except for those requiring forest clearance, no EIAs/EMPs have been submitted to the MOEFF
EPA, 1986	Prosecution for fouling the environment	DEPT OF ENVIRONMENT	unclear about enforcement role
MINES ACT, 1951 Mines Rules, 1955	Withdrawal of permission to mine, Mine closure	DGMS	Main constraint to monitoring arises from the unclear owner-operator relationship
FOREST CONSERVATION ACT, 1980	Withholding of permission to divert forest land	DEPARTMENT OF FORESTS	This Dept has been monitoring diversion of forest land; but has however not monitored afforestation by mining companies
TCP ACT 1981	Control over land use	DEPT OF TOWN & COUNTRY PLANNING	Believes that it has no jurisdiction over mining activity, however it should have a role to play if externalities cause changes in land use
IRRIGATION ACT, 1974	Control over Canals and the Supply of water	DEPT OF IRRIGATION	This Department has issued notices in recent times to the mining companies responsible for silting of canals

Figure 6.1 Existing institutional linkages and responsibilites for different department in Goa



Institutional requirements

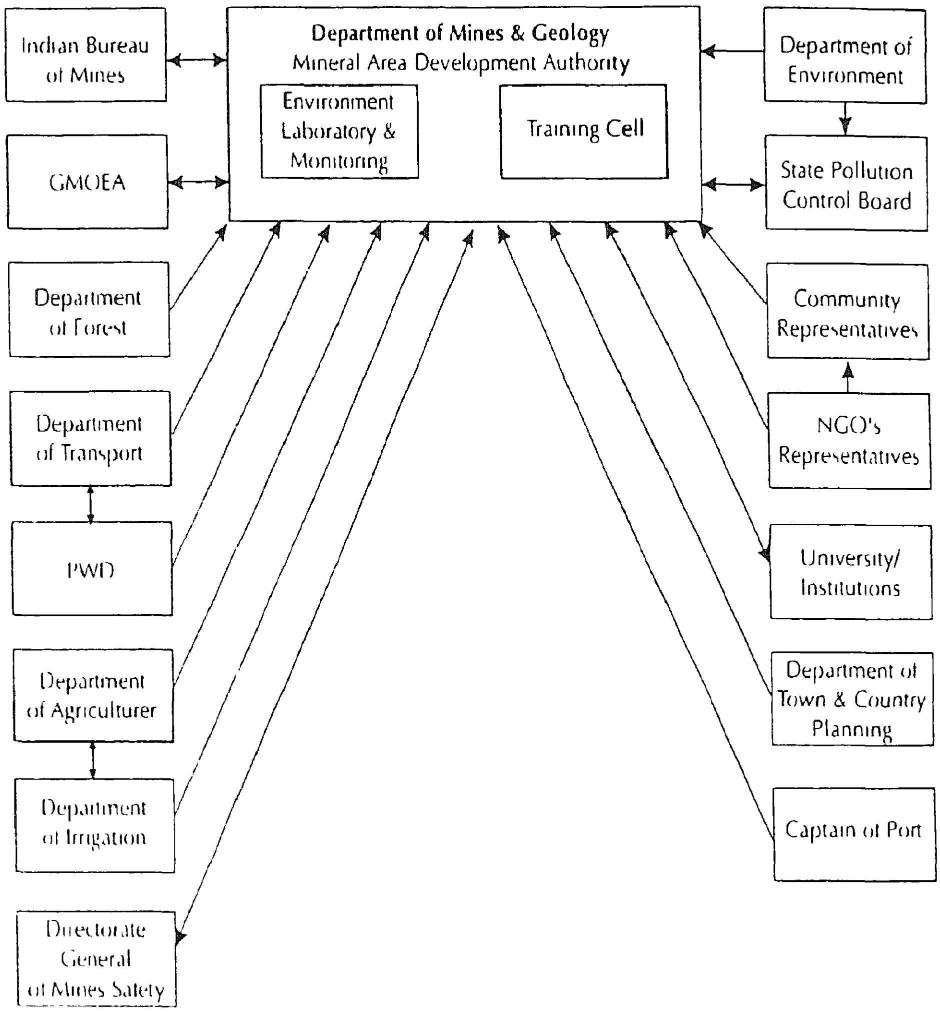
What is abundantly evident from this study is that having laws and regulations by themselves have not worked. The institutional capacity has been weak both in terms of ability and willingness to implement these regulations The mining companies have been operating very much in an 'implementation' vacuum, since most of the bodies charged with implementation have not taken their roles seriously An efficient and effective Management Plan will be possible only if the linkages between concerned agencies- governmental and non-governmental - are clearly identified and the responsibilities explicitly allocated To meet the challenge of abating environmental degradation and energizing improvement of the environment beyond the traditional regulatory measures, the state government should initiate some innovative steps.

Given the number of stakeholders in mining and a complete lack of co-ordination and networking amongst them, it is recommended that a **Mineral Area Development and Authority (MADA)** be established. This Authority should have representatives from the various concerned government agencies so that co-ordination and action can be planned, and effective. MADA should also have representatives from the mining associations, established NGOS, institution-based professionals and, by rotation, some of the Sarpanchas of the villages in the mining belt. This will ensure that all stakeholder's views are taken on board MADA should be the body to independently administer the funds collected through royalty and social and environment cess on iron ore as proposed in Chapter 5.

This authority should be empowered with the development of the area. In view of the environmental degradation and haphazard development of the area, it is clear that the various agencies involved with the mining sector have been unable to plan or implement suitable measures for improvement. MADA should be made accountable to implement the AEQM plan. It should have equal status with other ministries in the state government and should be headed by a dynamic person of senior rank to enable it to function effectively.

It is suggested that the department of industry and mining should be headed by a Secretary with Director (Industry) and Director (Mining) reporting to him. The Director (Mining) should also function as the Chairman of MADA MADA should have four divisions namely - monitoring, training; co-ordination and implementation; and R&D and demonstration studies Figure 6 2 shows the proposed institutional linkages for Goa Mining Industry. Table 6.2 shows the agencies responsible for implementation of the various measures in the AEQM plan.

Figure 6.2 Proposed institutional linkages for Goa Mining Industry



The main activities of MADA could be as follows:

- **Remediation of past environmental neglect for which no single mine owner can be held responsible.** More specifically the scope of activities under this heading can be as follows (I) Desilting of the main nullahs (ii) Creation of wetlands in abandoned pits (iii) landscaping of abandoned mine sites (iv) the creation of green belts on existing roads used intensively by mine companies (v) meeting the incremental costs of road improvements in main roads used by mine trucks (vi) mapping of abandoned mine pits and a quantification of water volumes on a monthly basis (vi) developing of ground water models for mining areas for forecasting and remediation of the adverse impacts of mining on the local ecosystems (vii) establishing a baseline crop productivity for the agricultural areas in the mining belt.
- **The Community development programmes.** To improve the social and economic conditions of the mining villages as well as to reinvest some of the mining wealth into building human capital in these regions with a view to aid the transition to a time when the mines are closed. The Social cess can be allocated for this purpose. The social programmes that need to be considered as a priority are: (I) an adult literacy drive (ii) introducing multi-skill training institutes (iii) ensuring water supply to the villagers (iv) providing toilets (v) improving access to health facilities in the mining villages. A co-operative movement strategy should be adopted in implementing these programmes
- **Co-ordination amongst various stakeholders to ensure that current mining operations use good environmental management practices** and monitor the implementation of environmental laws. These can include (I) a rainwater management plan that includes good dump management (ii) the use of closed water circuit systems where applicable (iii) the treatment of waste water before disposal if not being recirculated (iv) ensuring that trucks are not overloaded (v) to study the possibility of operating mines jointly in the Surla Pale Cluster to reduce environmental impacts. This body can also act as a conduit of best practices elsewhere in the world and facilitate the transfer of technology.
- **Training programmes** (I) for mine company staff to ensure improved environmental management in mines.(ii) for public education and awareness so as to improve the effectiveness of the measures put in place. (iii) for innovative community relationships that includes training and knowledge acquisition initiatives for staff as well as members of local communities
- Encourage the use of **Integrated Environment Impact Assessment, Auditing and Management Systems.** To improve the quality of impact assessments it is necessary that mining companies: (I) adopt more proactive and extended EIAs that incorporate social impacts, both temporally and spatially. (ii) Use social impact indicators to monitor societal effects over

time (iii) Promote stakeholder participation in the EIA process and within the EMS throughout the life of the mine.(iv) Improve social and environmental baseline information.

- **Regular monitoring** of ambient air, water and soil at a number of stations, selected in the area. The details of monitoring and environmental audits are given later in the chapter.
- Build up **data bases** on various aspects related to the mining belt using the services of local colleges and the University
- **Support Research and Development** into ore upgradation, enhanced metal recovery from tailings, bioremediation, etc and the promotion of demonstration and pilot projects to stimulate the development and diffusion of clean technology.

Table 6.2. Agencies responsible for implementation of the AEQM plan

	Abatement measures	Implementing agency	Regulating agency
1.	Dump rehabilitation, Tailing pond rehabilitation, Dust control in mining operation	Mining companies	IBM/Forest Department
2	Haul roads, screening plants	Mining companies	IBM/DGMS
3	Close-water circuit in beneficiation plants	Mining companies	IBM/SPCB
4	Pit water treatment	Mining companies	IBM/SPCB
5.	Garland drains, run-off control	Mining companies	IBM/SPCB
6.	Barges	Barge owners	Captain of Ports
7.	Mine and public roads improvement	PWD	State Government
8	Prevent overloading, covering of bricks, wheel wash system	Mining companies	DOT
9	New alleinate roads	PWD	State Government
10	Social welfare measures		State Government
	- Literacy	DOE	
	- Multi-skill development	DTE	
	- Sanitation and health	DOM	
	- Water supply	PWD	

Monitoring network for ambient environmental quality

It is suggested that MADA should be responsible for monitoring environmental quality in the area. To carry out this task effectively, a network of monitoring stations have been designed. These are discussed below

Air

Intensive mining activities and the transport of ore by open trucks through public corridors are deteriorating the ambient air quality in villages surrounding mines and traffic corridors. Villages having loading points are also affected considerably due to exposed ore stackyards and transport activities It is therefore essential to have ambient air quality monitoring stations in selected villages to assess the pollution levels throughout the year. This would facilitate to develop better management practices to ensure compliance with standards and protect human health. According to USEPA guidelines for network design. three factors are of paramount importance while selecting monitoring stations. These are:

- Source influences.
- Demographic influences.
- Meteorological influences.

Based on these considerations, a total of 8 monitoring stations have been proposed in the area as given in Table 6.3. The stations would be located in various mining and non mining villages to assess the status of ambient air quality. Monitoring of background concentration is useful to understand the contribution of pollutants due to mining activities to air environment.

Table 6.3. Air quality monitoring stations

No.	Proposed monitoring stations	Remark
1	Mulgao	Present intense activity, future expansion, high population density
2	Pale	Present intense activity, future expansion, high population density
3	Cudnem	Present intense activity, future closure, high population density
4	Cotombi	Loading points, high traffic, high population density
5	Codli	Present intense activity, future expansion, low population density
6	Sanvordem	Loading points, high traffic, very high population density
7	Calem	Background pollution level
8	Tudou	Present medium intensive activity, future expansion, low population density

Air quality monitoring schedule

The parameters SPM, SO_2 and NO_x would be monitored in each of the above 8 monitoring stations Respirable particulate matter (RPM) needs to be monitored in 5 villages namely Mulgao, Pale,

Cotombi, Codli and Sanvordem. In addition it is recommended that Pb and Co measurements are also carried out at Cotombi, Sanvordem, Codli. The air quality monitoring schedule is given in Table 6.4.

Table 6.4. Air quality monitoring schedule

Parameters	Period (hours)	Days/week	Measurements/year	Measurement method
SPM	24	2	104	Average flow rate not less than 1.1 m^3/min
SO_2	24	2	104	Improved West & Gaeke method Ultraviolet fluorescence
NO_x	24	2	104	Jacob & Hochheiser modified method Gas phase Chemiluminescence
RPM	24	2	104	
Pb	24	2/month	24	AAS method after sampling using EPM 2000 filter paper
Co	8	2/month	24	Non dispersive infrared spectroscopy

Weather monitoring

The following meteorological parameters are to be recorded on an hourly basis during the year in Velguem (North Goa) and Codli (South Goa).

- Dry and wet bulb temperature.
- Relative humidity.
- Wind speed and direction.
- Rainfall.
- Solar radiation.

In addition, atmospheric pressure, evaporation and cloud cover also need to be monitored at regular intervals

Water

The monitoring network needs to be established so as to check the efficiency of the control measures adopted to achieve compliance with the standards. The present enforcement mechanism as laid down by the Central and State pollution control Boards sets water quality standards with source specific controls devised for abatement of water pollution. Moreover, each source separately acts as a point source in defining a surface water body system. In other words, the water quality for surface water

bodies like tanks and rivers would depend on the efficiency of controls for industry. Water quality monitoring programme in the study area will have the following objectives:

- To check the compliance status of mining companies CPCB & IS2490 has laid down certain minimum effluent discharge standards. Therefore, it is essential to monitor the water quality parameter for the effluents arising out of mining activities for all these parameters
- To check the quality of the streams, rivers & groundwater so as to find their suitability for their designated use.
- To identify sources of pollution and to plan proper management strategy to maintain the quality of the river.

In the study area the most prominent uses of surface water are domestic and irrigation Irrigation water is classified on the basis of percent sodium and electrical conductivity. Since electrical conductivity is a good measure of dissolved salts, U.S. salinity laboratory has made the groupings of water as shown in Table 6.5. Excessive quantity of sodium in irrigation water tends to make the soil impermeable to air and water. Therefore, high sodium percentage will not only render the water unsafe for irrigation purpose but also gradually make the soil uncultivable. The most reliable index of salinity hazard in water is Sodium Absorption Ratio (SAR) which is the ratio in meq/l of Na^+ to the square root of one half the sum of Ca^{2+}, Mg^{2+}.

Table 6.5. Mineral and salinity classification of water

SAR	Class	EC (u mohos)	Class
<10	Excellent	<250	Excellent
10-18	Good	250-750	Good
18-26	Fair	750-2250	Permissible
>26	Poor	2250-5000	Unsuitable

Domestic water is used for drinking, bathing and washing In many villages inhabitants depend on the nearby streams or rivers for their domestic needs. Water quality in these streams should therefore meet Class A criteria for drinking and Class B for bathing If mine pit water is used for drinking, it should be treated. The quality parameters to be monitored are SS, FC, pH, hardness, SAR and heavy metals.

For water qualuity montioring, a total of 10 monitoring stations are proposed (eight for surface water and three for ground water). The sampling would be of the "grab" type since there is no possibility of variation in the quality of water over a period of 24 hours. The frequency of sampling should be once in a month as per the statutory requirements. The flow rate should be essentially

measured at the time of sample collection for the effluent stream. Flow rate is the product of velocity and surface area. The list of monitoring stations is given in Table 6.6.

Table 6.6. Surface and ground water monitoring stations

Station	Surface water monitoring station
1	Velvet river (down stream)
2	Maem lake
3	Mandovi river (down stream of Piligao)
4	Advoi nala
5	Madai river (down stream of Pale)
6	Khandaper river (up stream)
7	Khandaper river (down stream of Codli)
Station	Ground water monitoring station
1	Piligao village
2	Pale village
3	Codli village

Note: Monitoring the water level and water quality in dug wells within 5 km buffer zone for all the 4 seasons in a year

The parameters which need to be monitored are covered by the IS specification IS-2490 (part 1)-1981 However, the critical parameters would include pH, BOD, COD, TDS, TSS, total hardness, temperature, and Ammoniacal Nitrogen. Methods for determination of these parameters are given in Table 6.7

Table 6.7. Methods of determination of critical parameters of water, wastewater and monitoring schedule

Parameter	Recommended method
pH	Electrometric method
Velocity of flow	Current meter or float method
Dissolved oxygen	Iodometric method
Biochemical Oxygen Demand	Dilution method
Total Coliform	Multiple Tube Dilution Technique
Fecal Coliform	Multiple Tube Dilution Technique
Chloride	Argentometric method
Hardness	EDTA Titrimetric method
Calcium	EDTA Titrimetric method
Sulphate	Turbidimetric method
Sodium	Flame Photometric method
Potassium	Flame Photometric method
Chemical Oxygen Demand	Dichromate reflux method
Solids (TSS. TDS)	Gravimetric method
Turbidity	Nephelometer
Ammoniacal nitrogen	Calorimetry

Noise

Ambient noise level monitoring needs to be carried out in the industrial and residential areas of proposed industries. Equivalent noise level (Leq) is to be monitored in day (6 a.m. to 9 p.m.) and night period (9 p.m. to 6 a.m.) for ambient noise to comply with the standard prescribed by CPCB (Ambient Air Act, 1987). Sound exposure level (SEL) needs to be measured in all the places where people are exposed to noise sources in the mines to fulfil the standard of 90 dB(A) for 8-hrs of working period Monitoring of noise should be conducted once in four months. In addition, there should be facility to carry out the audiometric test for each worker working in the higher noise levels in the mines once in a year or two. The audiometric test will appraise the workers about their hearing status and the working environment.

Soil monitoring

Mined land reclamation has to be given prime importance. Therefore, soil samples from unmined areas and over-burden dumps should be collected once a year or at more frequent intervals depending upon the need. Soil samples should be analyzed for physical, chemical, biological and fertility characteristics. Soil is to be analyzed and tested for suitability for reclamation purposes (e.g. soil characteristics-particle size distribution, water holding capacity, pH, conductivity, organic matter, free ammoniacal nitrogen, potassium, phosphorus, heavy metals e.g. copper, lead, cadmium, hexavalent chromium etc).

The proposed soil monitoring stations would be in the villages Mulgao, Sirigao (cluster I), Cudnem, Honda (cluster II) and Codli, Santona (cluster III). Soil samples need to be collected and analyzed from the mine/dumps, midpoints and nearby agricultural fields to assess the impacts of silt runoff in agricultural fields.

Dust monitoring

Respirable dust survey should be conducted in all the operational points in the mine where people are exposed to respirable dust. Gravimetric Dust Sampler (GDS) and Real Time Aerosol Monitor (RAM-1) with data logger are the commonly used instruments for measuring the respirable dust emanating from the various sources in the mine. The dust survey should be conducted along with analysis of free silica once in four months to ensure the safe level of respirable dust of 3 mg/m^3 for 8 hours of working where free silica content in dust should not exceed 5 percent as prescribed by Directorate General Mines Safety (DGMS).

Ground level vibration

The monitoring of ground level vibration should be conducted once in two years to ensure safe blasting operation in the mine. Peak particle velocity is to be measured in nearly all residential and office buuildings during the monitoring of ground level vibration and should not exceed the safe limit of 12.5 mm/s within 300 m from the blasting site.

Investment for monitoring activities

MADA should be made responsible for continuous monitoring of the environmental quality in the area. A well equipped laboratory and monitoring equipments and instruments are essential before monitoring activties can be undertaken. The cost of setting up a monitoring network and laboratory facilities is estimated at Rs 44 lakhs. The operating cost is estimated at Rs 14 Lakhs per annum The details are given in Table 6.8. The equipments for laboratory are given in Table 6.9. This cost should be borne by the government and can be funded from the royalty fund collected by the government.

Table 6.8. Investment requirement for monitoring network

Equipment	No	Costs (Rs)
Capital cost		
Air quality		
High volume sampler	10	3,00,000
RPM-10 sampler	5	1,80,000
CO monitor	2	2,00,000
Weather monitor	2	3,00,000
Noise		
Noise level meter and frequency analyzer	2	6,00,000
Audio meter	1	3,00,000
Laboratory facilities		25,46,000
Total Capital Cost		44,26,000
Pollution monitoring		8,00,000
Laboratory		6,00,000
Total Operating Cost per annum		14,00,000

Table 6.9. List of equipments for laboratory facilities

No.	Instrument	Cost (Rs.)
	Air	
1	Atomic absorption spectrophotometer	12,00,000
2	Electronic balance (4 digit)	70,000
3	Real time aerosol monitor with data logger	1,50,000
4	Wind monitor with data logger	1,50,000
5	Hot plate	5,000
6	Laser based master particle size analyzer	5,00,000
7	Double distill water system (glass) (ion exchange unit)	60,000
	Spectrophotometer	
		80,000
	Water	
1	BOD incubator	25,000
2	pH meter	5,000
3	water analysis kit	65,000
4	Nephelometer	10,000
5	Water flowmeter	6,000
6	Flame photometer	15,000
7	Conductivity meter	8,000
8	Kjendhal unit	25,000
9	COD digestion unity with vertical condensers	72,000
10	Hot plate (already given in air)	5,000
11	Suction pump (GF/C) and BOD aerator	35,000
	Soil	
1	Flame photometer	15,000
2	Oven	15,000
3	Soil sampling tube	5,000
4	Soil moisture tester	5,000
5	Shaker machine for soil texture analysis	20,000

Environmental auditing

Introduction

"Environmental audit" is a technique being introduced for integrating the interest of the industry and the environment so that these could be mutually supportive. This technique is basically a part of industry's internal procedures in meeting their responsibilities towards better environment.

Environmental auditing is a management tool comprising a systematic, documented, periodic and objective evaluation of how well the management systems are performing with the aim of:

- Waste prevention and reduction.
- Assessing compliance with regulatory requirements.
- Facilitating control of environmental practices by a Company's management.
- Placing environmental information in the public domain.

Environmental auditing can be viewed as a 'management tool' internally, and 'liaison' externally with the public and regulatory bodies

Benefits of environmental audit

Environmental auditing has far reaching benefits to the industry, to the society and the nation at large The benefits of environmental audit are:

- Determines how well the process systems and pollution control systems are performing, and identifies the operations of poor performance.
- Identifies potential cost savings which can be accrued through reduction in raw material consumption by way of waste minimization, and adoption of recycle/recovery/reuse, resulting in reduction in pollution load.
- Increases awareness of environmental requirements, policies and responsibilities.
- Helps in understanding the technical capabilities and attitude of the environmental organization in a Company.
- Provides up-to-date environmental data base for use in plant modification, emergencies, etc
- Unravels surprises and hidden liabilities due to which regulatory risk and exposure to litigation can be reduced.
- Ensures independent verification, identifies matters needing attention, and provides timely warning to management on potential future problems.
- Helps to safeguard environment and assists in complying with local, regional and national laws and regulations, with the Company's policy and with the environmental standards.

CHAPTER 7

Conclusions and recommendations

The AEQM approach is a powerful problem solving technique for application to a wide range of situations and locations. The core of the approach is to integrate economics, ecology, technology and institutions to identify and evaluate alternative solutions to prevailing environmental problems. The objective of the present study is to devise a framework that guides the improvement of environmental quality of the area. To accomplish this, information for decision making is necessary The AEQM plan is intended to supply this information in a systematic, orderly fashion in order to open, not foreclose options The focus is on the generation of non-traditional approaches to environmental management, such as road improvements and diversions, close circuit (water) operations in beneficiation plants, greenbelts and using pit water as a source of drinking water in villages.

Present conditions

Present conditions in the study area can be summarized as follows:

- Iron ore mining is an important economic activity in Goa.
- Mining has been prevalent since the 1950s and has led to environmental degradation
- No effective measures have been taken to control land, air and water pollution
- The runoffs from the dumps, pit water discharge and the tailing pond overflow account for most of the sediment (TSS) loads in rivers/streams/nallahs. The worst affected rivers are Bicholim, Madei, and Kandepar. Some of the mines have their dumps right on the river banks from which there is run off directly into the rivers during the monsoon.
- Run offs from dumps has affected about 320 Ha of agricultural land due to silting
- Air quality index developed for the villages in the study area show that in many of villages the population is exposed to poor/bad air quality. Dust pollution is a problem in cluster II and III and along certain stretches of road corridors.
- Socio-economic study has identified many issues that are of concern to the villages Scarcity of water is common in all clusters but more acute in villages in clusters III and IV.
- Vocational training institutes are almost non existent in the villages. Alternate employment opportunities are very limited in the mining area.
- Sanitation facilities is almost absent in the villages.
- A total impact index (TII) was developed for each village taking into account environmental impacts and social conditions in the mining villages. 11 villages are highly stressed with TII >10 and 20 villages are moderately stressed (TII > 5 but < 10).

Future plan of activities (1997-2012)

The Goan iron ore production has reached a plateau and would remain at a level of 14-15 million tons per annum. It is projected that mining may decline or close down in 19 leases resulting in a loss of about 10 million tons of production capacity. To maintain the production at the existing level, expansion of mining capacity in some villages will occur leading to increased impacts in these villages. The people's opinion on the future of mining in Goa was also assessed through the socio-economic survey. Although the views of the people in many villages indicated that they would not like increased mining activity in their areas, there is no denying the economic dependence of the locals on the mining activity.

Management strategies

Business-as-usual scenario (BAU)

Since the production of iron ore in future is projected to remain at the existing level, the impacts on the environment due to mining and associated activities would continue in spite of the control measures being adopted by some companies. The net result would be a further deterioration in the status of the environment. About 1850 Ha of additional land would be required for mining which would be affected. Already there is a backlog of more than 800 Ha of land under dumps which has not been rehabilitated. The air quality index in 15 villages would fall under poor and bad category as against 12 villages at present. The erosion of waste dumps due to run-off and pollution of water bodies due to pit water discharge and beneficiation plant tailings would continue. For achieving the desired objective of good environmental quality in the area, four management strategies have been selected. The results are summarized below:

MS-1

This strategy includes planned improvements including additional control measures. The net benefits are as follows:

- Decline in TSS in pit discharge water is expected due to improved measures for settling of solids which include settling tanks, use of coagulants, filter beds and check dams. In addition, closed water circuit in beneficiation plants would result in reduced water requirements and low or nil discharge of solids into water bodies
- The quantity of waste material (overburden) due to mining is expected to remain more or less at the same level, but the net disturbed land under dumps is reduced from 830 ha to about 300 ha due to enhanced reclamation of damaged land.
- The tailings discharge from beneficiation plants would continue but tailing ponds would be rehabilitated
- Air quality improves significantly and the AQI in all villages is estimated as good. Therefore, the number of households exposed to high levels of SPM would be almost negligible.

MS-II

With improvements in mine roads and public roads and implementation of all dust control measures listed under MS-I, there would be a drastic reduction in generation of fugitive dust resulting in reduction in SPM levels along the road corridors. The alternative (new) roads for ore transport from South Goa mines would result in reducing dust levels significantly in the 3 towns - Curchorem, Sanvordem and Capxem. In addition, the ore traffic load on the existing roads would decline, resulting in less congestion and accidents on the roads.

MS-III

The measures under this strategy would greatly help in improving the quality of life of the people in the mining villages. The use of pit water for drinking after initial treatment at the mine and secondary treatment at a central location adjacent to the villages would reduce the water scarcity conditions in some villages during summer months. Vocational training institutes would help to upgrade the skills of the villagers opening up more employment opportunities. Another major advantage is the improvement in the company's image due to their involvement in community development activities in villages surrounding the mines.

MS-IV

Management strategy IV is a combination strategy incorporating elements from all three strategies. In effect if these elements are introduced into the mining belt, than what is obtained is integrated environmental management of the mining belt and the parallel concept of planning for closure from the outset of operations. For those mines, as is the case in this study, that are well into their project cycle it implies adopting an integrated approach from the point of entry up until the closure of the mine. Such an approach will ensure that mineral development remains competitive while contributing to the sustainable development of the region.

Cost analysis

The total investment is estimated at Rs 4500 lakhs for abatement measures in MS-I, Rs 11500 lakhs for improved roads and an additional Rs 4200 lakhs for alternate (new) roads under MS-II, and Rs 3275 lakhs for welfare measures under MS-III. Four control measures, namely, land rehabilitation, dust control, road improvement, and pit water treatment for drinking water supply, constitute the bulk of the investments. The impact of the cost of abatement measures under MS-I is Rs 7/- tonne of ore production and this cost should be absorbed by the mining companies. However, the rehabilitation of old waste dumps and abandoned mines and de-silting of stretches of rivers/streams affected due to past mining operations should be the responsibility of the government. The cost of these measures can be estimated only after a physical survey of the affected areas. This could be funded from the royalty fund being collected by the government.

Road improvements could be funded through a road cess on iron ore of Rs 14/t and welfare measures implementation can be funded through a social cess of Rs 5/tonne of the ore production. The net result of all these measures would be a substantial improvement in the quality of environment in the area. In addition supply of drinking water to affected villages and provision of sanitary and education facilities and development of economic activities in the mining areas would improve the quality of life of the population.

Better environment and improved welfare amenities may improve the productivity of the persons employed in the mines resulting in financial benefits to the company. Improved roads, apart from improving environment would result in less congestion and accidents and increased economic activity for the state.

Recommendations

For a successful AEQM study and its implementation it is of utmost importance that the major players actively participate in providing data and help to formulate realistic abatement measures in terms of costs and feasibility. Formulation of management strategies is fundamental to the AEQM method and this cannot be independently developed by the AEQM study team.

In spite of major problems like lack of data on emissions generation and discharge and future projections of iron ore production, etc., an attempt has been made to quantify the impacts, future production, cost of abatement measures under each management strategy. Cost data used in the analysis are rough estimates, especially for road improvements and welfare measures. An independent agency, MADA, under the department of industry and mines has been suggested to co-ordinate with various government and other agencies and be fully responsible for implementation of the AEQM plan. Funds for implementation is to be raised from royalty and various cesses proposed on iron ore.

Another major factor in implementing the plan are the political considerations. The following aspects need to be considered when presenting the plan to administrative authorities.

- Priorities of environmental problems in relation to other societal problems.
- Priorities of strategies within the AEQM plan.
- Inter-governmental relations (centre-state and state-district).
- Public acceptance.
- Obtaining the legal authority for the institution entrusted with implementation.

In the AEQM plan various abatement measures have been included under the different strategies. The major recommendations are as follows:

i. Implementation of abatement measures in the operating leases/mines should be the responsibility of the mining companies.

ii. The rehabilitation of abandoned pits and dumps and desilting of stream and nallahs due to past mining activities should be the responsibility of the government and can be implemented through the forest and irrigation departments.

iii. Studies are required to generate baseline data and information on runoff, soil erosion and siltation. These studies would help in designing cost effective control measures In addition they may help in dispensing with the system of arbitrary payment of compensation to farmers whose fields are silted in various degrees. A proper scheme, based on data, can be designed for loss in agricultural output and amount of compensation to be paid.

iv. The villages facing acute shortage of water for domestic needs have been identified A detailed survey should be carried out to identify the mines for supply of pit water to these affected villages. The suggested scheme for treatment of pit water is the use of granulated activated carbon (GAC) treatment. A pilot study is recommended for detailed designing of GAC coloumns and to decide the frequency of reactivation

v. It is important that the ground water studies on individual catchments in the entire mining belt of Goa should be carried out. This would help in preparing action plans for each micro-catchment level for implementation. In addition, the following studies are also recommended:

• Estimation of actual ground water withdrawals from mine pits on micro-catchment basis, using gauging methods and computation of recharge to ground from river beds and agricultural lands during non-rainy seasons.

• Aquifer parameter estimation both for shallow and deep aquifers through pump tests at representative locations.

• Development of ground water models for mining areas to assess impacts due to future operations.

vi. The improvement of mine roads and public roads should be taken up by the government. In addition, alternate (new) roads suggested by the Committee should also be finalised and taken up for construction by the government. The cost of road construction/ improvements will have an impact of Rs 14/tonne of ore production if the total cost is charged on iron ore production. The cost can be recovered from the companies in the form of a road cess. The government can decide as to how much of this cost has to be borne by the companies so that part of the expenditure is met from government budget for roads.

vii. The task of improving welfare measures in the mining and other villages in the area should be the responsibility of the government and the mining companies. A social cess of Rs 5/tonne of ore production is recommended to meet the proposed expenditure.

viii. Ambient environment quality monitoring of the area should be the responsibility of MADA to generate base-line data on air, water, soil, land, ecology, etc. and for initiating corrective actions wherever required.

ix. R&D experiments for upgrading the quality of Goan ore and value addition to the ore should be undertaken by MADA. In this connection, the scope of cost effective pelletization of Goan ore can also be examined.

x. Merger of adjacent mining leases for more efficient operation resulting in improved economics and environmental control should be promoted.

xi. Setting up of small and medium industries for agro-based products, building blocks from waste overburden material, engineering units, etc. should be promoted. In addition, dairy development projects in mining villages can be encouraged.

xii. An integrated strategy (MS-4) will ensure that mineral development remains competitive while contributing to the sustainable development of the area.

Bibliography

Almeida, J. C.1997. Economic Times

Government of India. 1991. District Census Handbook, Census of India - village and town directory. Registration of Census, Government of India, New Delhi.

Central Pollution Control Board. 1983. Water pollution- An overview. CPCB, New Delhi. Programme Objective senes: PROBES/11/1982-83.

Central Pollution Control Board. 1996. Pollution control acts, rules and notifications issued thereunder. Pollution control senes: PCL/2/1992 (Volume-I). New Delhi.

Central Pollution Control Board. 1979. Scheme of zoning and classification of Indian Rivers. CPCB, New Delhi, ADSORBS/3/1978-79.

Chachadi, A. G. 1997. Impact assessment of open cast mine dewatering on local and regional ground water regimes in Goa. Report submitted to TERI, Western regional centre, Panaji, Goa.

Champion H G and Seth S K. 1968. Forest types of India. Manager of publication, New Delhi.

Dhar Bharat B and D. N. Thakur, 1995. Mining Environment, Centre Mining Research Institute, Dhanbad.

Indian Institute of Technology. 1992. Final report: Environmental impact of iron ore mining in Goa through remote sensing. CSRE, IIT Bombay.

Forest survey of India. 1996. The state of forest report 1995. Forest survey of India, Dehra Dun.

Ganihar S R. 1990. Impact of mining on the faunal composition of Goa. Ph.D Thesis. Goa University.

Geological Survey of India. 1985. Earth Resources For Goa's Development, A collection of Seminar Papers, The Director General, Geological Survey of India, Calcutta.

Goa Mineral and Ore Exporters' Association. 1997. Goan Iron Ore Industry - Historical background and present status. Panaji, Goa.

Government of Goa. 1995. Statistical pocket book of Goa. Directorate of planning, statistics and evaluation, Government. of Goa, Panaji.

Government of Goa. 1988. Regional plan for Goa 2001 A.D. Town and Country Planning Department. Government of Goa, Panaji.

Government of Goa. 1992. The Report of the Agricultural land development panel. Submitted to the Chairman of the Panel the Hon. Minister for Revenue, Government of Goa, Panaji.

Government of Goa. 1996. Draft Annual Plan (196-1997). Directorate of Planning, Statistics and Evaluation, Panaji, Goa.

Government of India. !996. Report of sub-group on Iron and Steel for the IXth Five year Plan. Ministry of Steel, Government of India, Delhi.

Government of India, Ministry of Steel & Mines, Indian Bureau of Mines, Export Potentialities of Iron Ore from India, Controller General, Indian Bureau of Mines, Nagpur

Indian Bureau of Mines. 1994. Environmental aspects of mining areas. Publication cell, Nagpur.

Indian Bureau of Mines. 1995. Circulars issued to recognized qualified persons by The Chief Controller of Mines. Nagpur. IISM, Nagpur.

Indian Bureau of Mines. 1995. Study of environmental pollution control measures in Goa. Nagpur.

Kalavampara Glen. 1994. Preliminary assessment of salt water-fresh water interface between Fort Aguada and Candolim coast North Goa. Department of Geology, Goa University, Taleigao Plateau, Goa.

Joshi S G. 1984. Air quality indices. Training programme on air pollution monitoring and management, held at IIT Bombay

Lokayan Bulletin 1994. Development projects and rehabilitation of displaced persons. 10:5/6. pp 151-153.

Ministry of Environment and Forests. 1992. Policy statement for abatement of pollution. Government of India, New Delhi.

Mitchell Mark K, Stapp William B. 1993. Field Manual for Water quality monitoring. An Environmental Education Program, Green Project. University of Michigan,

Michigan, USA.

Modassir M. 1994. Impact of current iron ore mining activities on the environment of Goa and proposed measures to minimise long term environmental and economic damage. MBA Thesis, University of Hull, UK.

Munn R E. 1981. The design of air quality monitoring networks. McMillan Publication Ltd., London.

Federation of India Mineral Industries. 1996. National Seminar on Indian Iron Ore and Steel Industry : Vision 2012, Proceedings Volume 1, Nehru Place, New Delhi.

Nayak G N. And T S S Rao. 1993. Studies on sediment flux of rivers, estuaries and adjoining coastal waters of Goa, West Coast of India. Project Report submitted to Ministry of Environment and Forest, Government of India, New Delhi.

Nayak G N. 1994. Impact of mining on environment in Goa: Present status. Ph.D. thesis, Goa University, Panaji. Project sponsored by, Ministry of Environment and Forest, Government of India, New Delhi.

Nayak G N. 1995. Impact of mining and physio-chemical changes due to siltation in Mayem lake and other water bodies of Bicholim taluka, Goa. Goa University. Project sponsored by the Ministry of Environment and Forest, New Delhi.

NBSS & LUP. 1995. Soils of Goa for landuse planning. National Bureau of soil survey & Land Use Planning, Bangalore.

Ramakrishna T L. 1996. Mineral Exploration in Goa - New horizons. Geological Survey of India. In: One day Workshop on Integrated mineral exploration programme in Goa - A vision workshop proceedings souvenir. Panaji, Goa.

Samat L D. 1989. Environmental management and reclamation in iron ore mines of Goa. In: National seminar on protection of environmental and ecology by mining industry. Vol. I and II.

Shetty S M, S R Garubar and K G Hiremath. 1987. Effects of mining on the ecosystems of Sanguem, Bicholim, Satari & Quepem Talukas: Goa, Technical Report - I. Department of Environment, Forests and Wildlife, Government Of India, New Delhi.

Sinha Subrato. 1991. Measurement and frequency analysis of noise emanating from various opencast mining machinery. M. Tech. Thesis, Indian School of Mines, Dhanbad.

Sinha Subrato and Sridharan P. V. 1997. Ground level vibration in surface mines- An

environmental concern. Indian Journal of Environmental Protection, March, pp 171-174.

Sinha Subrato and Banerjee S. P. 1996. Evaluation of the effectiveness of a chemical dust suppressant on haul road in an Indian opencast iron ore mine.The Indian Mining and Engineering Journal, December, 1996.

Sinha Subrato and Banerjee S.P. 1997. Characterisation of haul road dust in an Indian opencast iron ore mine. Atmospheric Environment, UK, Vol.31, No.17, June, pp.2809-2814.

Soil survey staff.1992. Keys to soil taxonomy. 5th edition, SMSS tech., Monograph no.19, Blacksbury VA, USA.

Torne S G and R V Goankar.1989. Response of plant species to the mining sites situated at Pale & Sirigao, Technical Report, 1986 - 1989.

Triggs D M and Bertram A J. 1989. Control of pollution in mining industry project Goa (India)-waste water treatment by aided settlement and horizontal flow roughing filters. Proc. National Seminar on protection of environment and ecology by mining industry, vol.3, A-39 to A-60.

Trivedy R K and M P Sinha. 1990. Impact of mining on environment. Ashish publishing house, New Delhi.

Vijayan, Vinita C K. 1996. Rehabilitation of Harvale Mine, Goa. Dissertation submitted for Masters of Landscape Architecture to School of Planning and Architecture, New Delhi.

Warhurst, A & L Noronha (forthcoming). Planning for Closure: Best practices in Ecological Management & Mining St. Lucie Press, UK.

Western Coalfields Ltd. Noble Explochem Ltd. Nagpur. 1994. The impact of mining on the environment- problems and solutions. A A Balkema/Rokltterdam and Oxford & Ibh Publishing Co. Pvt. Ltd.

Williams R B and Culp G L. 1986. Handbook of public water system. Van Nostrand Reinhold company, New York.

World Health Organization . 1977. Air monitoring programme, offset publication, No. 33. WHO,Geneva.

Standards and regulations

ISI:5182 (Part 14). 1985. Method for measurement of air quality: Guidelines for planning the sampling of atmosphere and location of monitoring station.

ISI. 1969. Indian Standard Method for Measurement of Air Quality. IS:5182 (Part II)

ISI. 1973. Indian Standard Method for Measurement of Air Quality. IS:5182 (Part IV)

ISI. 1975. Indian Standard Method for Measurement of Air Quality. IS:5182 (Part IV)

ISI. 1985. Indian Standard Method for Measurement of Air Quality. IS:5182 (Part III)

ISI. 1969. Methods for measurement of air pollution for dustfall. IS:5182 (Part I).

Land Acquisition Act. 1894 (with State Amendments and Short Notes), Sixth Edition. 1994.

Mines and Minerals (Regulation and Development) Act. 1957, 1994. Ministry of Mines.

The Environmental (Protection) Rules. 1986. Ambient Air Quality Standards in respect of noise.